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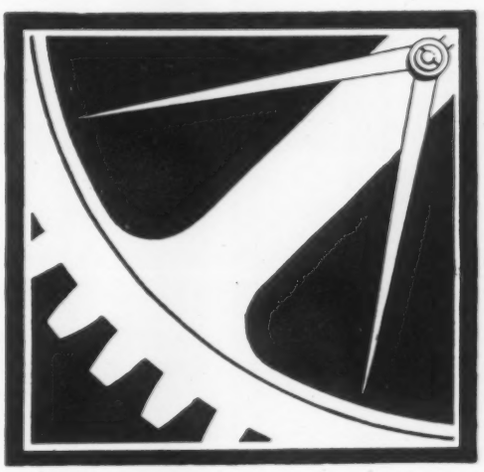

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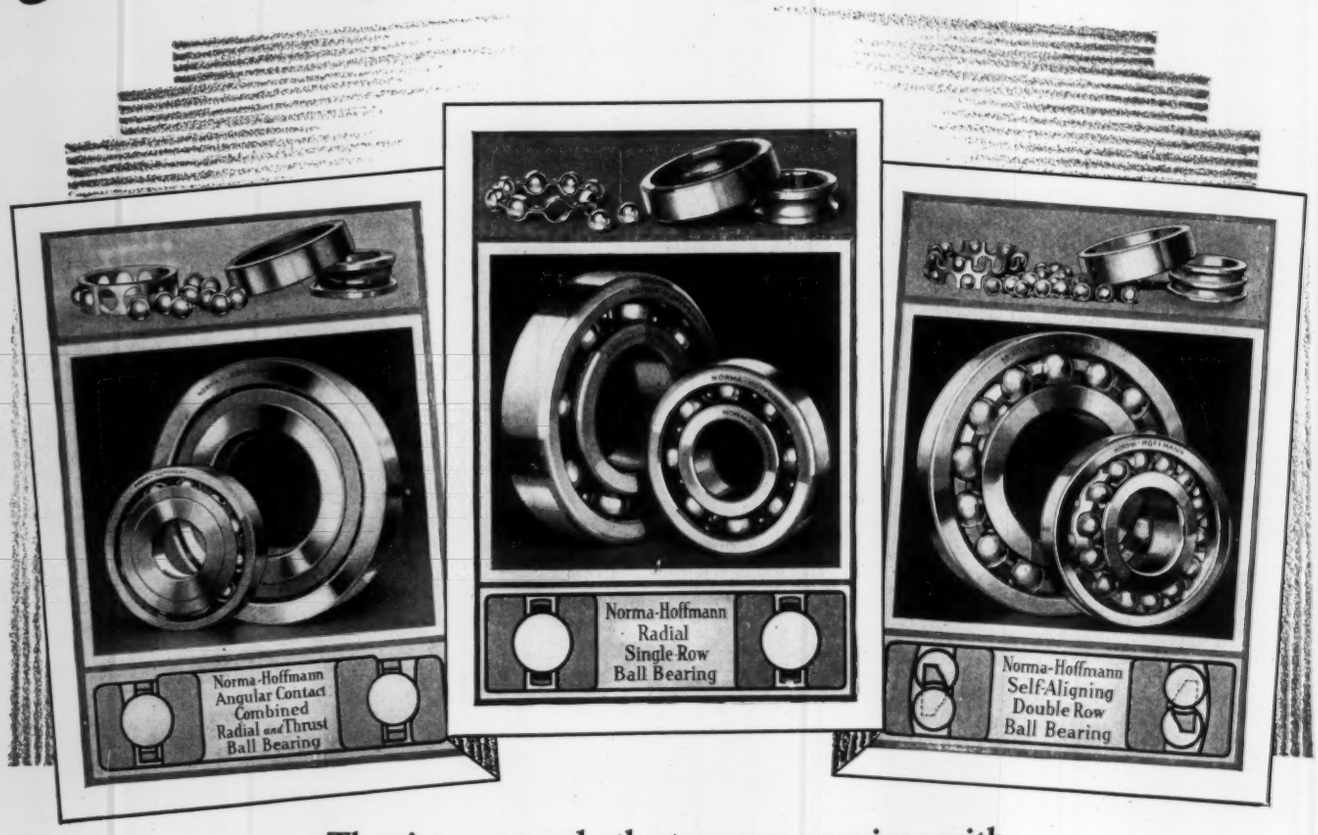

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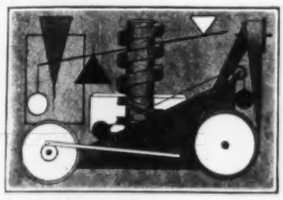
Volume 2 | July, 1930 | Number 7



In This ISSUE

READERS agree that MACHINE DESIGN *is covering its field in a thorough and authoritative manner. Taking the contents of this issue as an instance, there are articles on subjects as diversified as designing for light weight, organization of the engineering department, and consideration of the human factor in design.*

Future issues also will contain carefully selected and sufficiently diversified contributions. And in the major design articles, as in the past, every effort will be made to disseminate material of value not only to engineers connected with design of machines similar to those treated in the articles, but to others engaged in designing unrelated types of machinery.

L. E. Jermy.

Managing Editor

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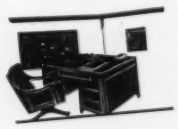
Organization and Supervision of Design Department

By John J. Hardecker



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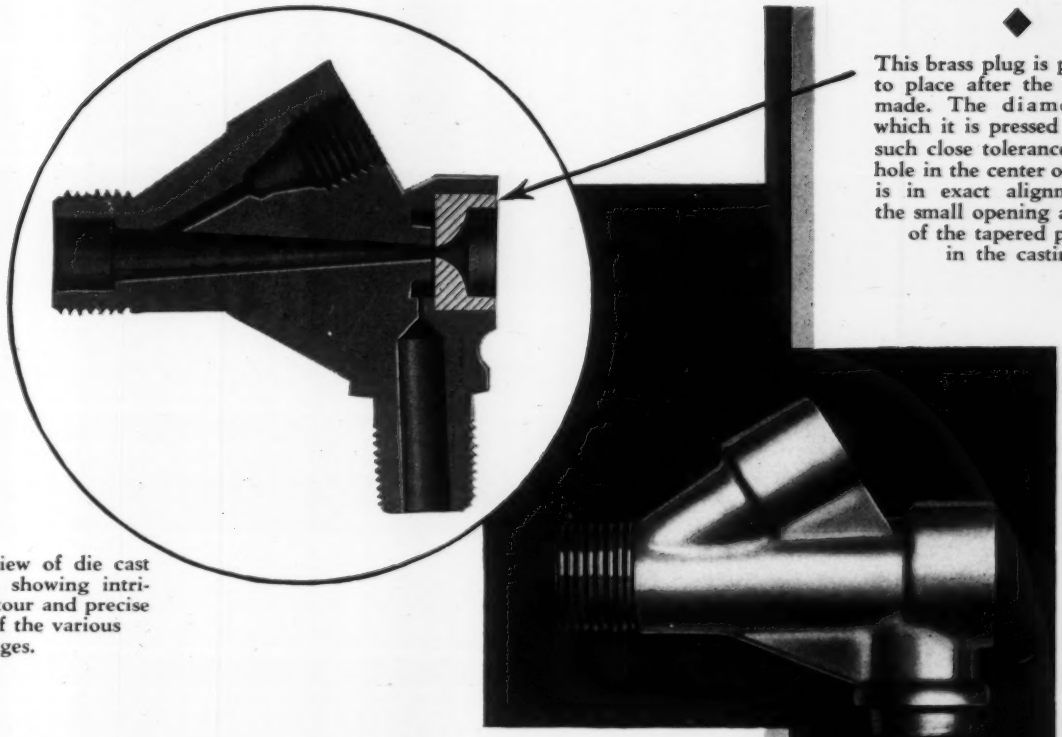
In response to the many requests, the series of articles which appeared in Machine Design a short time ago, dealing with the management of engineering departments, has been reprinted in a 32-page booklet.

Subscribers wishing copies for themselves or their engineering departments are invited to send in their requests.



This brass plug is pressed into place after the casting is made. The diameter into which it is pressed is cast to such close tolerance that the hole in the center of the plug is in exact alignment with the small opening at the end of the tapered passage in the casting.

Cross-sectional view of die cast vacuum booster, showing intricate interior contour and precise relationship of the various passages.

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Die Casting this part has greatly simplified its manufacture. Costs have been materially reduced and it is no longer necessary to rely upon costly, precision machining operations to insure the exact relationship of the various openings and passages.

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2. All holes and air passages are cast in.
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4. Internal thread is tapped after casting is made.
5. Interior surfaces are cast exceptionally smooth.
6. The casting is delivered complete, ready for assembly.

MILWAUKEE
DIE CASTINGS AND BEARINGS

CALENDAR OF MEETINGS AND EXPOSITIONS

Aug. 24-29—International Congress for Applied Mechanics. The third congress to be sponsored by this organization will be held at Stockholm, Sweden. One the evening of the first day an informal reception-ceremony will be held at the Academy of Engineering Sciences and sessions will be carried out in the Royal Technical university, beginning the following day. German, English, French and Italian languages will be used. At the first session hydrodynamics and aerodynamics covering the theory of propulsion and the problem of resistance will be discussed. The second session will embrace the theory of elasticity and strength of materials including stability and strength of thin-walled constructions, limit of rupture and theory of plasticity, while the third-session will bear on rational mechanics and problems of oscillations. Correspondence should be addressed to Prof. W. Weibull, general secretary Third Internationl Congress for Applied Mechanics, Klg. Tekniska Hogskolan, Valhallavagen, Stockholm, Sweden.

Aug. 26-28—Society of Automotive Engineers. Aeronautic meeting to be held in conjunction with National Air Races at Chicago.

Aug. 31-Sept. 7—International Congress for General Mechanics. Meeting in Liege, Belgium. For information address Alb. Schlag, 4 Place Saint-Lambert, Liege, Belgium.

Sept. 8-13—National Association of Power Engineers. Annual convention and exhibition of power machinery at Cleveland Auditorium, Cleveland. Fred W. Raven, 417 South Dearborn street, Chicago, is secretary of the association.

Sept. 22-26—American Welding Society. Annual fall meeting to be held at Congress hotel, Chicago. W. M. Spraragen, 29 West Thirty-ninth street, New York, is technical secretary of the society.

Sept. 22-26—American Society for Steel Treating. Annual meeting to be held in connection with the National Metal exposition at Stevens hotel, Chicago. W. H. Eisenman, 7016 Euclid avenue, Cleveland, is secretary of the society.

Sept. 22-26—American Institute of Mining and Metallurgical Engineers. Annual fall meeting of the institute of metals division at Stevens hotel, Chicago. W. M. Corse, 29 West Thirty-ninth street, New York, is secretary of the institute.

Sept. 22-26—American Society of Mechanical Engineers. Annual fall meeting of iron and steel and machine shop practice divisions to be held at Stevens hotel, Chicago. P. T. Wetter, 29 West Thirty-ninth street, New York is secretary of the society.

Sept. 22-26—National Metal exposition. The twelfth annual congress and exposition sponsored by five national technical societies will be held at Stevens hotel, Chicago. Technical sessions, the annual meeting of the American Society for Steel Treating, and other features of the congress all will be held in the hotel. The 1930 show will cover approximately 75,000 square feet of floor space. Heavy displays and machinery will occupy the exhibition hall and foyer on the first floor and the second floor exhibits will be located in the grand ball room and its foyer, and in the lounge, writing room, and main dining room of the hotel. W. H. Eisenman, secretary of the American Society for Steel Treating, is director of the exposition.

Sept. 29-Oct. 1—American Gear Manufacturers association. Fall meeting to be held at Hotel Clifton, Niagara Falls, Ontario. T. W. Owen, 3608 Euclid avenue, Cleveland, is secretary of the society.

Sept. 29-Oct. 3—National Safety Congress. Nineteenth annual meeting to be held at Fort Pitt and William Penn hotels, Pittsburgh. Metals section meetings will be held Tuesday and Wednesday mornings and Thursday afternoon.

Oct. 7-10—American Road Builders' association. Sixth international road congress Washington auditorium, Washington. An exhibition of the best products of the American highway machinery manufacturers will be held simultaneously with the congress. Delegates from 56 countries will study the exhibits to acquaint themselves with the trends in design of equipment built in this country.

Oct. 20-25—Dairy and Ice Cream Machinery and Supplies association. Annual exposition in Cleveland. Roberts Everett, 225 West Thirty-fourth street, New York, is secretary.

Dec. 1-5—American Society of Mechanical Engineers. Annual meeting to be held in New York. Calvin W. Rice, 33 West Thirty-ninth street, New York, is secretary of the society.

Dec. 1-6—National Exposition of Power and Mechanical Engineering. To be held at Grand Central Palace, New York. Charles F. Roth, Grand Central Palace, New York, is manager.

MACHINE DESIGN

July 1930

Factors Involved in Developing Light Weight Design

By Earle A. Ryder

QUESTIONS involving weight-strength ratios crop up constantly in the design of many types of machinery. With the increasing introduction of new alloys this subject assumes a position of paramount importance. While Mr. Ryder, assistant chief engineer, Pratt & Whitney Aircraft Co., tackles the matter from the angle of aircraft engine design, his discussion will be found extremely valuable to engineers in many other fields.

IN REDUCING the weight of any machine the work of the designer not only covers the size and shape of various parts but necessitates consideration of materials available, manufacturing facilities that can be employed and inspection methods that are feasible. It goes without saying that light weight design involves higher stresses than need to be considered in other types of machinery. For this reason it is essential that the materials used be selected suitably and that the methods of inspection employed be sufficiently rigid to insure that any materials going into the finished product will be sound and will have the strength and other physical properties specified.

The aircraft engine is a good example of light weight design because here the only factor more important than lightness is reliability. All other considerations are studied with a view to their effect on the weight of the finished product. Materials available to the designer range in specific weight from bronze on the one hand to magnesium alloys on the other. An analysis of a radial air-cooled engine showing weight distribution among various materials is set forth in Table 1.

In spite of the high specific weight of steel,

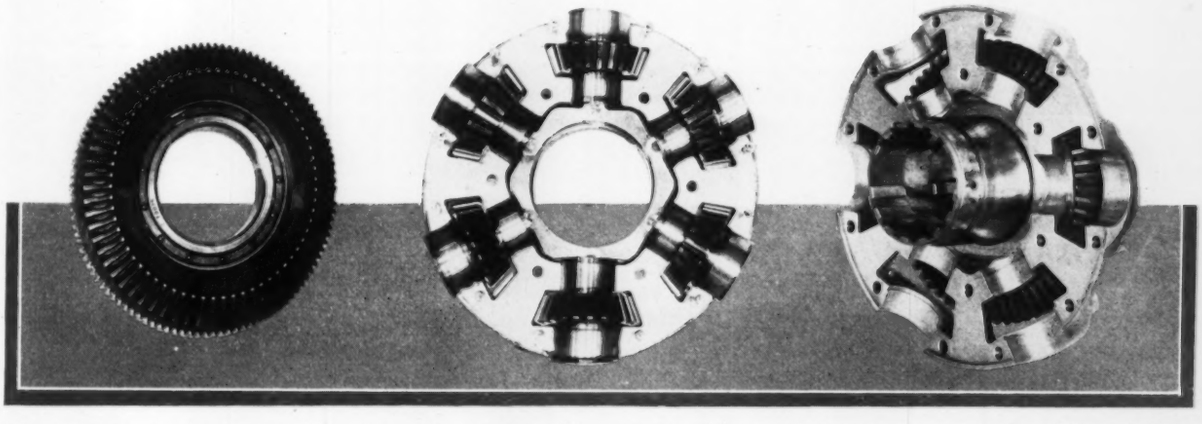


Fig. 1—Reducing gears for propeller drive. Formerly three pinions were used. Six pinions utilize twice as many teeth in large gears, permitting lighter construction

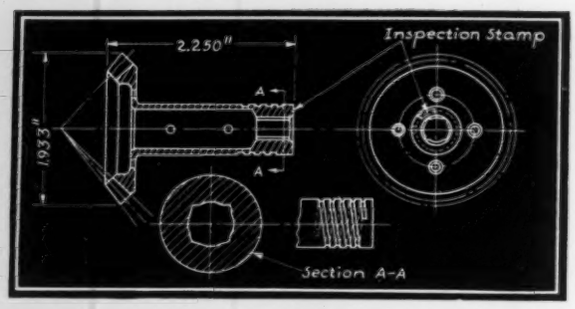


Fig. 2—Fuel pump drive gear showing use of light section of material

about half the engine weight is in this material. Reference to Table II will throw further light on this fact. The last two columns of the table show the relative strength of equal weights of the various materials, based on the yield point and the tensile strength, respectively. It is seen that in case of parts where strength is the prime consideration, alloy steel is superior to the lighter alloys in spite of the great difference in specific gravity.

Yield Point Frequently Is Low

This particularly is the case in parts which cannot be allowed to have any permanent deformation from the original shape, i, e., they cannot be stressed beyond the elastic limit. Indeed this includes almost all machine parts. While the ultimate strength of the light alloys is fairly high in proportion to their specific gravity, the yield point is low in some cases. For these reasons parts which must be designed especially for strength generally will be made of steel, while parts of intricate shape often can be made of cast aluminum or magnesium alloys to good advantage. Stiffness of light alloys, that is to say the modulus of rigidity, is much less than that of steel but as a general rule the thinness of the sections used will be limited by what the foundry can do, so that there is seldom any difficulty in having the required stiffness. The figures given in Table II are representative of actual results obtained in quantity manufacture of aircraft engines and represent materials used widely for this class of work.

It may be of much interest to designers to examine some specific examples of detailed parts employing the various materials. Chrome vanadium steel S. A. E. No. 6150 is used for piston pins, accessory drive gears, gear shafts, studs and bolts. For the latter parts it is heat treated before machining and is used at a lower state of strength and hardness than is given int he table. The figures were obtained on piston pins. Chrome nickel steel No. 3140 is used for crankshafts, connecting rods and other forgings. The 5 per cent nickel steel No. 2512 is used for case hardened crankshafts, cams, reduction gears and other highly stressed parts which require a hardened surface.

Grain Is Important Factor

Since steel is not a homogenous material but has a well defined grain, this is an important consideration in highly stressed parts. The strength of a piece of steel is much greater with the grain than across it, and it therefore is required to have the grain flow arranged in the most advantageous direction. In the case of crankshafts the grain structure is made to follow the journals, webs and crankpins, so that a continuous grain is secured from one end of the shaft to the other with no cross grained structure in the load carrying parts.

In the case of gearing, a radial grain structure is desired so that all teeth will have equal strength. Flat bar stock has, of course, a lengthwise grain and gears forged flatwise from this kind of material retain much of the original grain structure. The teeth on two sides of the gear thus will have long grain and on two sides at 90 degrees will have cross grain. To obtain the proper structure the forging must be upset from a small bar, and the designer should specify just what is wanted, not leaving it to the forge shop. It is a good precaution to check one or two forgings from each lot by deep etching which makes the grain flow of the metal quite easily visible.

Coming to the light alloys, dural in the form of

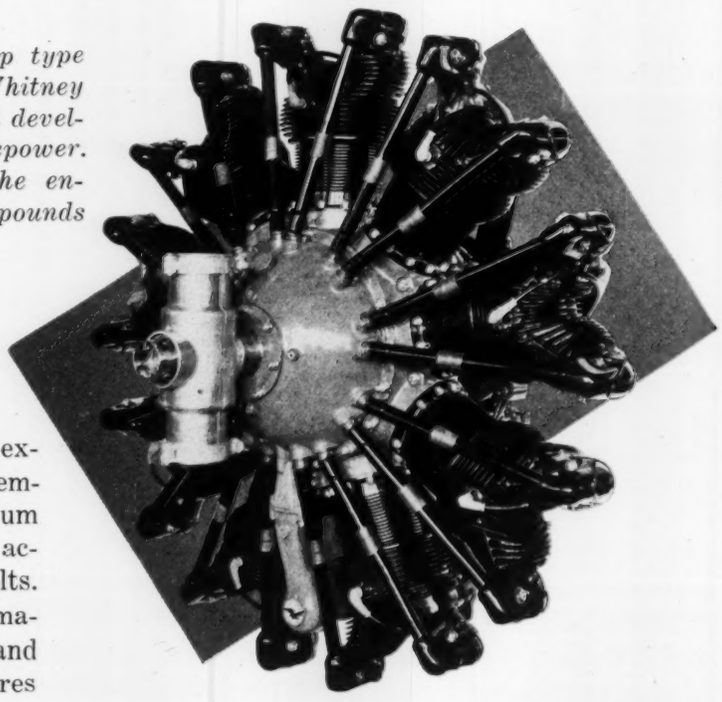


Fig. 3—Wasp type Pratt and Whitney engine which develops 450 horsepower. Weight of the engine is 685 pounds

forgings or bar stock is used for numerous small parts such as spacers, bolts, nuts, etc. Large forged parts of the engine such as the main sections of the crankcase, the nose section, thrust bearing cover, cam drum, are made of No. 51 ST alloy. It has been common practice to use castings for engine crankcases and this part therefore is a good example of what can be done by a designer by disregarding old customs and considering only what is fundamentally desirable. By making the crankcase in two identical halves, split in the plane of the cylinders, it was possible to use a forging and thus employ a material of high strength and be assured of perfectly sound material. This is difficult if not impossible in the case of castings. The case is heat treated after forging and then is restruck for straightening so that the finished forgings require little allowance for machining. They are not machined at all on the large flat surfaces. A typical crankcase is shown in Fig. 7.

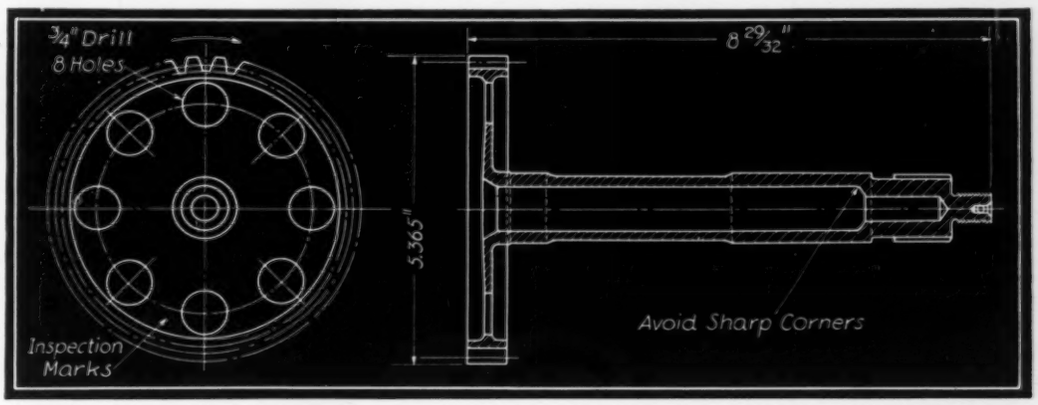


Fig. 4—Starter gear illustrating efforts which have been made to eliminate excess metal, with consequent reduction in weight

Cylinder heads and other intricate cast parts are made of No. 34 aluminum which is an alloy containing about 10 per cent of copper. This material has a fairly high yield point and lends itself to production of non-porous castings of complicated shape. In the use of the light alloys consideration must be given to operating temperatures. Most of the alloys used for cast aluminum parts lose something like one-half their strength of 600 degrees Fahr. and have only one-fourth the strength at 700 degrees Fahr. that they have at room temperature.

Magnesium Has Numerous Uses

Magnesium is going to be more of a factor in the production of light machinery as the price is reduced, and it is well adapted for small brackets, covers and housings. It also can be used for large castings such as some sections of an engine crankcase. One objection to the use of this material is its low yield point which in the case of a common alloy is only 9500 pounds per square inch in the sand cast and heat treated condition. Considerable improvement is made if the parts can be forged as the yield point then may be raised to as much as 22,000 pounds per square inch.

Close Inspection is Necessary

Inspection is a function that is or should be under the control of the engineering department and in building for light weight, it is necessary that the inspection department be well organized. It is hardly possible to overdo the inspection of material for vital parts. As an example of this, crankshafts for Pratt & Whitney engines are kept in separate lots and marked with the heat number. A chemical analysis is made of each heat and individual bars are inspected for seams and other surface defects. They also are tested for heat treating properties. A test section cut from every bar is given a hot acid test to determine soundness and this is followed by a micro examination of another specimen before the steel is approved for forgings. Each forging is marked to identify it with the mill and heat number so that reference to the records may be made to trace every shaft to a definite source.

Highly stressed parts not only must be properly designed but require the smoothest possible finish and a total absence of deep scratches or tool marks which might form starting places for cracks. Finishing all over often is necessary to facilitate inspection as well as to insure the absence of surface imperfections. The master connecting rod shown in Fig. 6 is an example of this. The part weighs 4 pounds in the rough forging and is reduced to less than 10 pounds in the finished part. It not only is machined all over but is polished. The finished piece is given a light etch in Nital (95 per cent alcohol, 5 per cent nitric acid.) This is carried only far enough to make the surface appear gray. Any hair lines or other surface de-

fects are magnified. After a thorough inspection the part is baked for one-half hour at 400 degrees Fahr. to drive off hydrogen and prevent embrittlement. After baking, it again is polished and a further inspection made. Defects which may have

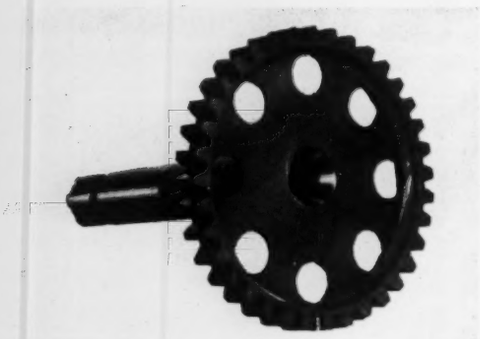


Fig. 5—Though section is thin, lightening holes are drilled in gear web

escaped the first inspection now will be seen without much difficulty.

One of the hard things to make the engineering department and shop thoroughly understand is the importance of avoiding sharp corners. Fillets should be as large as possible, especially on highly stressed parts; and not only that but they also should be smooth or even polished. No measurable scratches or tool marks can be tolerated at such points. Shafts which are bored out for lightness must have the same attention paid to the interior surface. It generally is hard to make a proper inspection of such holes and for this reason parts such as connecting rods may be made of I section instead of tubular. This makes it possible to examine the whole surface minutely, instead of relying on inspection of outer faces only.

Location of inspectors' stamps or other markings should be given careful consideration and generally needs to be specified on the drawings instead of being left to the discretion of the workman. There seems to be a strong disposition to bear down on the hammer when stamping small parts and cases have been seen where the web of a small gear only 1/16-inch thick was stamped with four or five figures and a couple of hyphens after great care had been taken to design it with generous fillets and grind the surfaces all over!

TABLE I

Weight Distribution in Engine

	Per cent
Dural	7.59
Other Aluminum Alloys	37.38
Magnesium Alloys	2.14
Steel and Iron	48.40
Copper, Brass, Bronze	4.21
Rubber, Paper, Asbestos, etc.	.28
	100.00

These figures apply to bare engine without accessories. Nine-cylinder radial engine of 450 horsepower.

Section Shape Is Controversial Point

Light weight design implies the best possible use of the material employed. This may be illustrated by the shank of the connecting rod. Some designers employ the I section while others favor the H section. Viewed parallel to the piston pin axis the connecting rod is a pin ended column but viewed at right angles to this it is a square ended column. From a consideration of the compression forces alone the I section therefore is indicated. In addition to this the whipping forces are applied in the direction which also requires the I section for greatest strength. In this case the easier manufacture of the H section is outweighed by requirements of strength and safety.

The reduction gear shown in Fig. 1 is another instance of the economic use of material. One usually would expect large gears to be necessary for the transmission of 600 horsepower. The gear set illustrated however, has this capacity and weighs between 40 and 45 pounds. This result is accomplished by using 6 pinions. The mounting of the pinions is arranged so that the load is equalized automatically on all six. This insures that each pinion carries its share of the load and permits a low safety factor.

Fig. 6—Master connecting rod with a link rod in place. One advantage of the I section is that the whole surface of the rod may be inspected closely, which would be impossible with rods of tubular cross-section

A general principle of great value is the mounting or location of load carrying parts so that the forces imposed on them are limited to the natural forces of operation and are not increased by the deflections of other parts. Gears which are driven from the crankshaft are subject to excess loading from torsional or lateral deflections of the shaft. This loading often can be reduced or eliminated by separate mounting of the driving

TABLE II

Specific Strength of Common Materials Used in Aircraft Engine Design

	Specific Gravity	Yield Point	Tensile Strength	Y. P. 1000 x SP. G.	T. S. 1000 x SP. G.
6150 Chrome Vanadium Steel	7.85	253,000	262,000	32	33
3140 Chrome Nickel Steel	7.85	125,000	140,000	16	18
2512—5% Nickel Steel	7.85	176,000	185,000	23	24
Dural	2.8	30,000	56,000	11	20
34 Aluminum (10% Copper)	2.9	20,000	25,000	6.9	8.6
51 ST.	2.75	30,000	45,000	11	16
Magnesium, sand cast and heat treated	1.8	9,500	33,000	5.3	18
Magnesium, forged	1.8	22,000	34,000	12	19

Above figures for yield point and tensile strength are average values taken from actual production work. The materials listed are representative, but comprise only a small fraction of those available.

gear and cushioning through a spring drive or friction clutch. Interfering factors which are important in the design of light weight machinery for heavy duty often are things that do not need to be considered at all in the design of heavy machinery. Deflections of supporting parts may redistribute loads causing concentration of stresses in unexpected quarters. The proper alignment of bearings is a matter of the first importance and must be kept in mind in designing light weight housings. It is possible to save weight to the extent of losing necessary stiffness, although the strength of the parts is sufficient.

Periodic vibrations in shafts, springs and even in parts which are not called moving parts also may cause stresses many times as great as the ordinary loads due to normal operations. Unusual conditions should be considered as to possible effects on stresses. An example that comes to mind is the oil pump drive. At the time of starting, the oil will be cold and viscous and the power required to operate the pump will be considerable. There also is the possibility of taking in bits of solder from an oil tank which has not been properly cleaned and which is not equipped with a strainer. It has been found worth while to make aircraft engine pumps sufficiently rugged to handle even this kind of material.

Rational Versus Empirical Design

There often is a clear division between parts which can be designed on a theoretical strength basis and those which must be designed mainly from experience with perhaps a check calculation to prevent making some bad mistake. In aircraft engines parts such as the starter shaft, certain bearings, minor driving shafts which are steadily loaded, studs, and springs not subject to vibration, can be designed on a rational basis. On the other hand the crankshaft, crankcase, master connecting rod, are subject to forces which do not yield to calculation and must be designed from experience and results of long continued testing. Such apparently simple matters as the attachment of counterweights to the crankshaft sometimes are troublesome on account of tuning fork vibrations which synchronize with the customary operating speed of the engine. In these cases two or three times as much material may be necessary in the crankarms as would be assumed from a consideration of ordinary forces.

Torque Is Limited by Clutch

The starter shaft and gear shown in Figs. 4 and 5 is an excellent example of a part which can be made just strong enough for its purpose. The prevailing type of aircraft engine starter is operated by the momentum of a small flywheel which is turned up to a high speed by manual or other means. Starting is accomplished by connecting the flywheel to the engine crankshaft through a suitable gear train and clutch. Torque which can be applied by the starter to the shaft is limited by the clutch so that the maximum stresses can be predicted within close limits. In the case of this part, we have a very good check

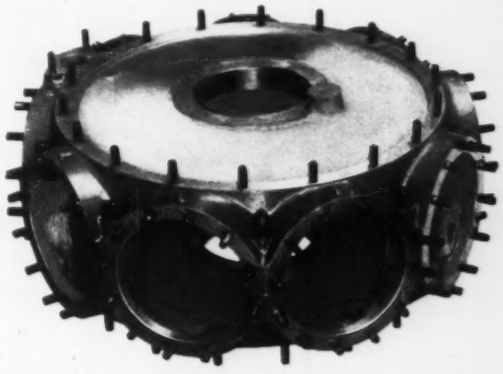


Fig. 7—Forged aluminum is employed for this crankcase assembly

on the starter shaft design if none have broken in ordinary service, but it is found possible to break the shaft if the starter clutch is locked.

Achievement of light weight along with other necessary requirements of a given design is possible only by minute attention to small but important details, a few of which have been touched upon in this article. It is hoped that the specific cases will be helpful to designers in general.

SCANNING THE FIELD FOR IDEAS

A Monthly Digest of New Machinery, Materials, Parts and Processes, with Special Attention to Significant Features and Trends in Design

DIFFERING radically in design from the generally accepted type of speedboat, Miss England II, the hydroplane in which Sir Henry O. D. Segrave recently lost his life, is said to have been the world's fastest boat. Though bristling with novel features from stem to stern she could not in any manner be classed as a freak.

The boat was planned carefully from data obtained in building an earlier model, Miss England I, which undoubtedly was one of the most efficient hydroplanes ever built.

Perhaps the outstanding feature of Miss England II was the propeller drive. Whether this feature was responsible for the fatal accident is not known but the fact remains that it showed teriffic speed. Two 12-cylinder Rolls Royce airplane engines of 2000 horsepower each were installed well aft and arranged to drive through separate shafts to a special gear box, located forward of the step. This gear box was built to transmit the power to one propeller shaft which passed through the hull in the usual way and was supported aft of the propeller by a strut. In Fig. 1 may be seen a cutaway section of the boat showing the two engines aft and a single gear box well forward.

Hydroplane designers, until last year, were of the opinion that it was impossible to use more than 500 horsepower in a single screw hydroplane because of the high torque of the propeller or, in other words the tendency of the boat to revolve around the propeller. With a twin screw boat, such as Miss America VIII there is no torque problem as the propellers revolve in opposite directions and the torque is equalized. The British designers, however, in working out the design of Miss England II decided that the under water resistance of two struts, shafts and propellers would be double that of one shaft, propeller and strut and that if possible it would be better to employ the single screw drive. To eliminate the factor of torque as much as possible the propeller used was of only 15 inches diameter and 14 inches pitch but it revolved at 12,000 revolutions per minute. No such propeller speed had ever before been attempted. Questions arise as to whether propellers can be produced to operate at these high speeds and whether the propeller shaft will function satisfactorily without whip at such revolutions.

The Hull of Miss England II really is built around the engine bearers, forming a particularly strong and rigid craft. Duralumin was employed extensively in the plates connecting the various pieces and also in the sheets for the ceiling of the hull inside the frames. One of the factors which undoubtedly had a strong bearing on the extremely high speed reached by Segrave's boat was the low powerweight ratio. Whereas the airplane which won the Schneider cup last year, registering the highest air speed ever attained weighed 3.86 pounds

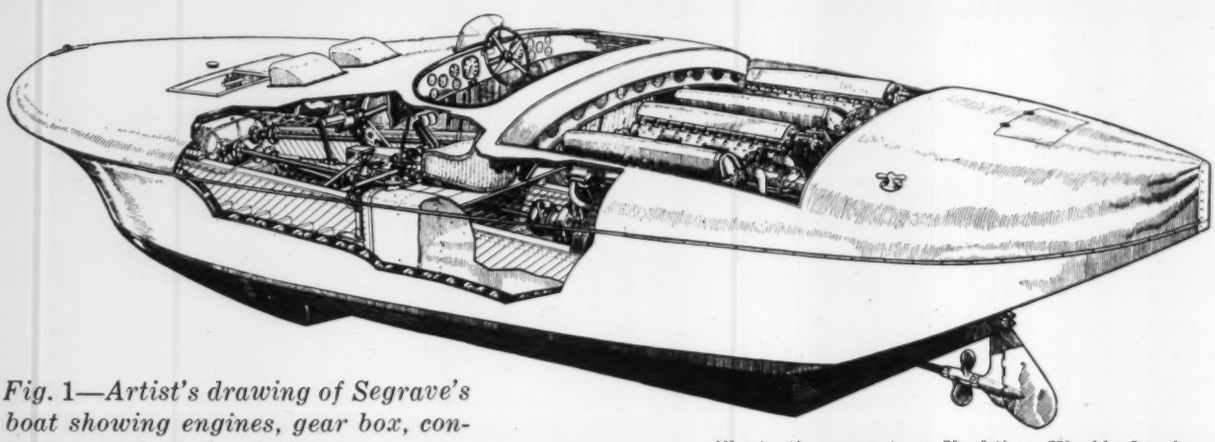


Fig. 1—Artist's drawing of Segrave's boat showing engines, gear box, controls, drive shafts, etc.

Illustration, courtesy Yachting World, London

per horsepower. Miss England II, with full gasoline tanks, oil, helmen and mechanics, had a power-weight ratio of only 3.23 pounds per horsepower.

Driving by Oscillating Axle

A NOVEL use for the planetary gear type of drive is illustrated by the oscillating axle developed recently for application to motor vehicles. This subject was discussed by Alain Madle, Relay Motors Corp., in a paper presented at the semi-annual meeting of the American Society of Mechanical Engineers in Detroit.

In this axle, shown in Fig. 2, the load is suspended at the end of an arm which swings in

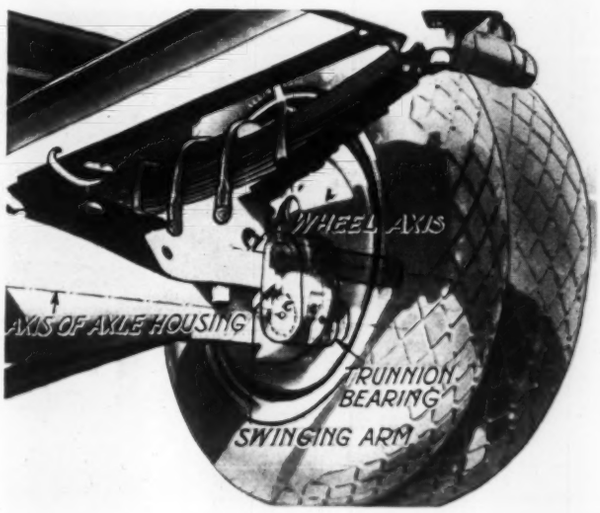


Fig. 2—Oscillating axle has planetary gear drive in which sun wheel is attached to road wheel. Planet is carried by swinging arm

pendulum fashion about the road wheel center. Fastened to the wheel, which is mounted rotably about a dead axle or stub shaft, is the track gear of the epicyclic drive. The power line is enclosed in an axle housing which, by means of the spring, carries the weight of the vehicle. The swinging arm carries on its one end the dead axle, and on the other end a trunnion bearing for the axle housing and a bearing for the track pinion which is in mesh with the track gear. Fig. 3 presents a diagrammatic illustration of the arrangement of gearing.

In the case of the conventional type of vehicle with a positive connection between the power line and wheel, the required torque must be transmitted by the sliding clutch because of the fact that the engine delivers torque only above a certain minimum speed. In other words, the vehicle has to be started before the clutch can be fully engaged. If

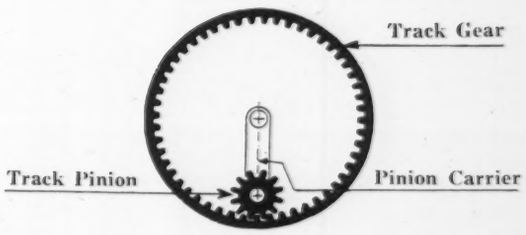


Fig. 3.—Diagram of planetary gear drive

the torque required to start the movement of the vehicle is greater than the torque which can be transmitted by the sliding clutch, the engine will stall when the clutch is fully engaged.

However, on a vehicle with oscillating axle it is not necessary to slide the clutch and bring the vehicle to a start before fully engaging it. Because of the vertical components of the inertia forces caused by the up-swing of the mass when the track driving pinion tends to ride up the internal gear, the weight utilized for traction is considerably increased, and only in exceptional cases will the applied torque exceed the available traction. Because of the additional propelling force, the vehicle with the oscillating axle can be started with a smaller amount of engine torque, and accordingly with less circumferential force on the tire.

Among the other advantages claimed for the oscillating axle is that it provides an elastic connection between the power line and rear wheel, thus cushioning torsional impacts that would be encountered under road conditions with a rigid axle.

Develop Rotary Valve Motor Head

WILL rotary valves for combustion motors become popular? The question is occasioned by announcement of an improved valve head of this type developed and patented by J. L. Smith,

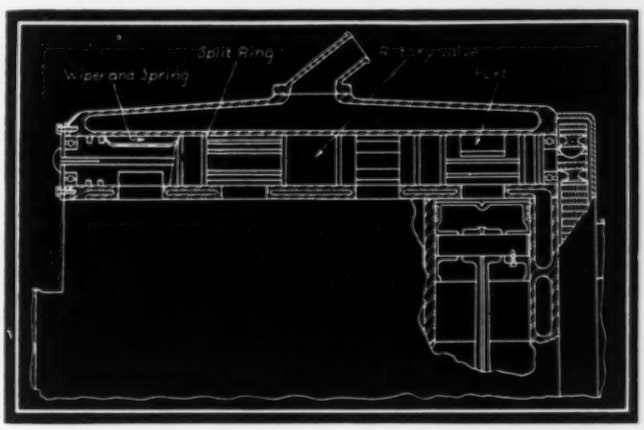


Fig. 4—Part section of motor with rotary valve head showing wipers and split rings

and F. L. Gushard, Viking Pump Co., Cedar Falls, Iowa. A cutaway section of the engine is shown in Fig. 4.

One of the difficulties encountered in the design of earlier rotary valve engines, was the amount of wear which took place on the periphery of the

Fig. 5—Illustration shows method of attaching ice prevention overshoe to wing

valve. In this new head, however, special means have been adopted to eliminate leakage of fuel or lubricant. Annular split rings, held in position by bushings, are positioned at intervals along the valve to prevent leakage lengthwise from port to port. Longitudinal sealing devices or wipers also are provided around the periphery of the valve, seated in grooves on bow-shaped flat springs, in the bottoms of the grooves.

In order to assist in cooling the valve, it is drilled from end to end to provide a passageway for oil pumped from and returned to the engine. Simplicity, silent operation and efficiency are claimed for the new engine head, rendering its operation equal, and in many respects superior to, the present poppet valve type.

Prevents Ice Formation on Wings

DIFFICULTIES encountered due to the formation of ice on the wings and other exposed surfaces of airplanes have been overcome successfully by a device developed at Cornell University. By means of it the ice, particularly in thin layers, can be moved and the "vacuum broken."

The device, shown in Fig. 5, takes the form of a light weight, thin rubber overshoe or pneumatic nose, for leading edges only, with a fabric backing for strength. In the leading edge of this overshoe is an air tube strengthened by extensible fabric, and a rubber oil-holding layer is over the surface. The inner tube is connected by pressure tubing to a pump, either motor or hand driven.

When ice forms the pilot turns air into the tubes, slightly expanding them. This moves the ice and since adhesion to the oiled rubber is essentially nil the ice becomes loose and is blown off. Expansion of the tubes is small and therefore change in aerodynamical characteristics of the wings need be but temporary and slight. The overshoes are made to lace on quickly, with no consequential disturbance to the stresses of any part of the plane.

Builds General Purpose Machine

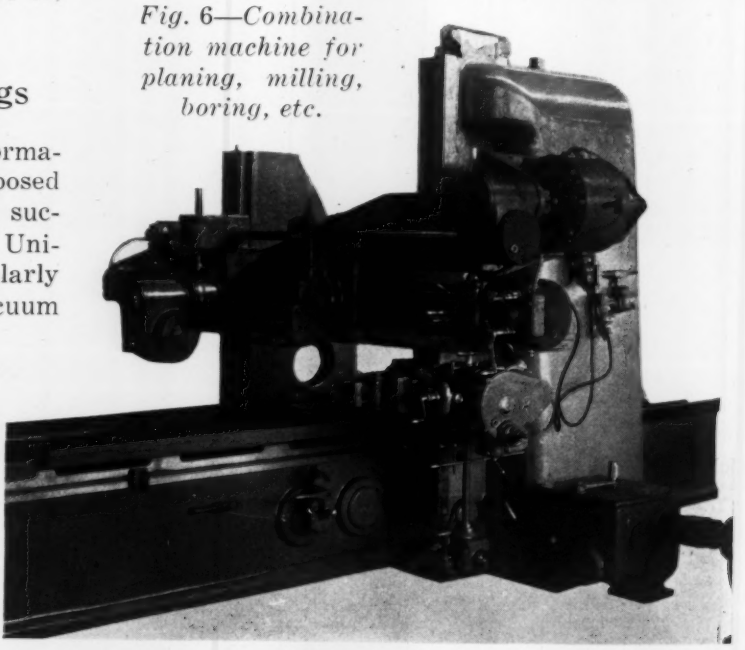
WHILE in these days the tendency is for machines to become more and more specialized, i.e. built to perform a certain specific operation, instances are found here and there of combination units. An example of such a machine is shown in Fig. 6 which illustrates a unit capable of performing planing, milling, drilling or boring operations. The machine has been developed by the Liberty Machine Tool Co., Hamilton, O.

In the illustration may be seen the universal milling head, which can be swung to any position angularly for straight or peripheral milling. The same head is used for drilling and boring. On the left of the machine is the feed box controlling the feeds of the milling head, either vertically or horizontally, and on the right of the rail is the planer head control.

The table can be slowed down to 1 inch a minute travel in either direction and the gearing is so arranged that the table also can be speeded up to the regular planing rate when desired.

For plants not on mass production, combination machines built along the lines of this machine tool often are a distinct asset. This particularly is

Fig. 6—Combination machine for planing, milling, boring, etc.



the case in contract engineering where quantities are small and more time is apt to be spent in setting up than in machining.

Electro-Magnetic Test Method

METHODS of testing, in which the engineer connected with design in many branches of the industry necessarily is vitally interested, are undergoing rapid change. Introduction of the X-ray process for detecting flaws, particularly in castings, already is well established and a new electro magnetic method recently was developed in England.

The apparatus for the latter, according to an article in *Automotive Industries* consists of a magnetizer comprising a coil, core and pole pieces, these latter being so shaped as to be capable of good magnetic contact with the ends of the part

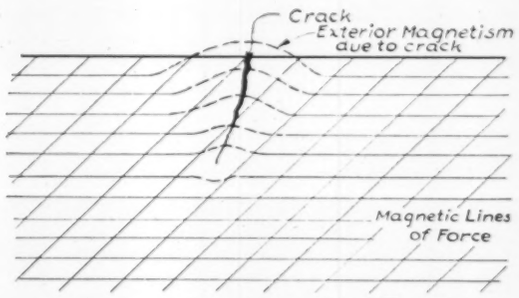


Fig. 7—Principle of electro-magnetic method for detecting flaws

to be tested. The magnetizer must be energized by direct current. When current flows through the coil, magnetic lines of force are created in the core, and these pass through one of the pole pieces into the part to be tested and return through the other pole piece to the core. A crack anywhere in the magnetic path increases the resistance to the flow of magnetism. Some of the lines will pass straight across the gap at the crack, but not as many as would flow through this section if there were no crack. More lines of force then pass through the sound section of the part, and some jump the gap on the outside of the part, passing through the air surrounding it.

These magnetic lines of force jumping a surface crack are detected by what is known as a detecting ink. This ink contains fine iron filings, which latter, by the magnetic effect on them, are drawn into the most intensive magnetic field outside the piece under test, that is, directly across the crack, and whenever a crack exists a black line is formed along the length thereof by the testing ink. The deeper the crack the greater the number of magnetic lines that are forced out into the air, and the broader will be the black line of detecting ink across the surface of the piece.

It has been found that it is necessary to control the magnetic force in accordance with the size and magnetic permeability of the part being tested, for if the steel is super-saturated some magnetism is crowded out into the atmosphere even where there is no defect, which may lead to false readings.

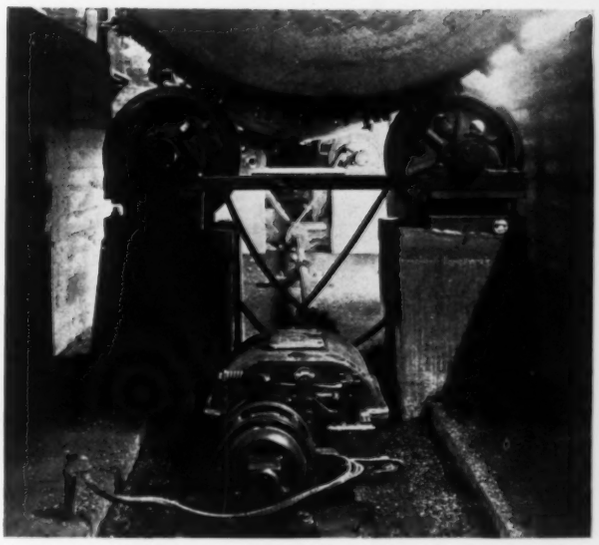


Fig. 8—Large cylindrical shapes are rotated by mechanical equipment during fabrication

Power Rolls Rotate Cylinders

PROBLEMS involved in the fabricating of large equipment often are difficult to solve, not always on account of weight but often due to the unwieldiness of the products to be handled. But that such difficulties may be overcome by comparatively simple expedients is proved by the method adopted by the Pressed Steel Car Co., McKees Rock, Pa., in the manufacture of tank cars. Similar schemes already have been applied in other phases of the industry, such as in the fabricating of stills for oil refineries; however, the arrangement under discussion embodies refinements which render it noteworthy.

A shown in Fig. 8, the equipment used for rotating the tanks during fabrication consists of several sets of power-driven rolls. The rolls are rubber-tired on account of their having to pass over the steeple-headed rivets in the cylinder seams. Steel rolls would not climb the $\frac{3}{4}$-inch high rivet heads particularly with the heavy dome traveling in an upward direction.

Power is transmitted to the rolls from a $2\frac{1}{2}$ horsepower motor, through a herringbone speed reducer, flexible coupling and chain drives. The latter, together with the reduction unit, chain drives and rolls, were furnished by Link-Belt Co., Chicago.

General Considerations in Designing Mechanical Springs

By A. M. Wahl

Part III—Springs of Square and Rectangular Wire

THIS third article of Mr. Wahl's series presents further valuable data on the design of springs. It is shown that, in many instances, the commonly used formulas for designing helical springs of square and rectangular wire deviate considerably from the correct values. More exact formulas, based on the author's research work, are suggested.

HELICAL springs of square wire have frequent practical applications, one advantage being that the load deflection characteristic may be adjusted accurately by grinding off the outside of the coil. To calculate the stress in such springs axially loaded, the author would like to recommend the following formula:

$$S = K\frac{Pr}{.208b^3}$$

where

$$K = \frac{4c-1}{4c-4} + \frac{.615}{c}$$

and may be taken from the curve of Fig. 2 in Part II of this series. In this formula,

P = axial load on spring
r = mean coil radius in inches
b = average side of square cross-section in inches
S = maximum shearing stress in pounds per square inch
c = spring index = ratio $2r/t$ where t = thickness of section in a direction perpendicular to the axis of the spring (Fig. 1)

The term $Pr/.208b^3$ represents the maximum stress in a square bar having a length of side of square cross-section b, acted on by a twisting moment Pr as calculated by the torsion theory developed by St. Venant, which practically all authorities on elasticity agree is the correct theory to use. The factor K represents a correction factor which takes into account the effect of spring curvature in increasing the stress. For our purpose we take K equal to the same factor as used for round wire (Equation 4 in Part II). Tests made as described below indicate that this method of calculation will give results sufficiently accurate for practical work.

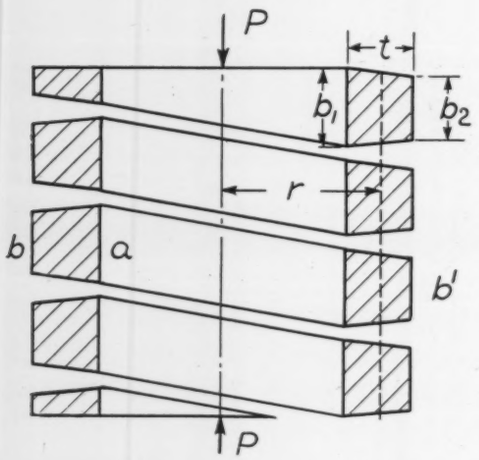


Fig. 1—Helical spring of square wire axially loaded. Wire becomes trapezoidal due to coiling

In coiling a spring of square wire it usually becomes somewhat trapezoidal as shown in Fig. 1. This is true particularly if the index is small. In calculating this case, the author has found that for stress a good approximation will be had by taking b as the average side of the trapezoidal cross-section.

For calculating the deflection in a square wire spring we use the formula

$$\delta = \frac{44.6\ Pr^3n}{Gb^4} \qquad (1)$$

This again is based on St. Venant's torsion theory. In this,

δ = deflection of spring in inches
G = modulus of rigidity in pounds per square inch
n = number of active coils

Other symbols are as in the foregoing. Since tests on round wire springs indicate that for practical purposes the spring index does not have

a big effect on deflection we do not multiply this formula by some factor such as K, as is done in the case of stress.

In the design of helical springs of rectangular wire axially loaded as shown in Fig. 3, we use the following formula for maximum stress

$$S = K \frac{Pr(3b + 1.8t)}{b^2t^2} \quad \text{.....(2)}$$

In this,

t = thickness of rectangular cross-section in inches
b = width of rectangular cross-section in inches
P = axial load on spring in pounds
K = same as for square cross-section

This formula also is based on St. Venant's torsion theory for bars of rectangular wire. The stress computed for a rectangular bar under a moment Pr then is multiplied by a factor K depending on the spring index to take into account the increase in stress caused by the curvature of the spring.

It should be noted that this formula only holds if the long side of the rectangle is parallel

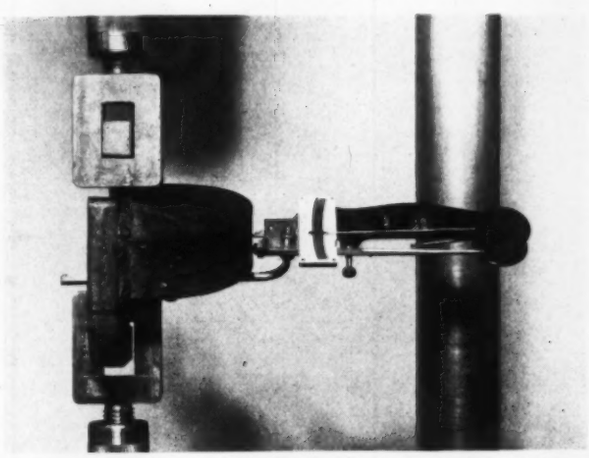


Fig. 2—Test with extensometer on outside of coil cut from actual spring

to the spring axis as shown in Fig. 3. In case the long side of the rectangle is perpendicular to the spring axis, a rough approximation will be had by taking $K = 1$ and interchanging b and t in Equation (2). Further research, however, is needed on this point.

For the deflection of a rectangular bar spring, we use the formula

$$\delta = \frac{19.6\ Pr^3n}{Gt^3(b-.56t)} \quad \text{.....(3)}$$

where

δ = deflection of spring in inches
G = modulus of rigidity in shear in pounds per square inch
b = side of rectangle parallel to spring axis in inches
t = side of rectangle perpendicular to spring axis in inches
n = number of active coils

In case the long side of the rectangle is perpendicular to the spring axis (if $b<t$) then b and t should be interchanged in Equation (3).

In order to check the accuracy of these formulas, some tests were made by the author. The method was to cut out a half coil from a helical spring of square wire and weld to it two pieces to form the arrangement shown in Fig. 2. The

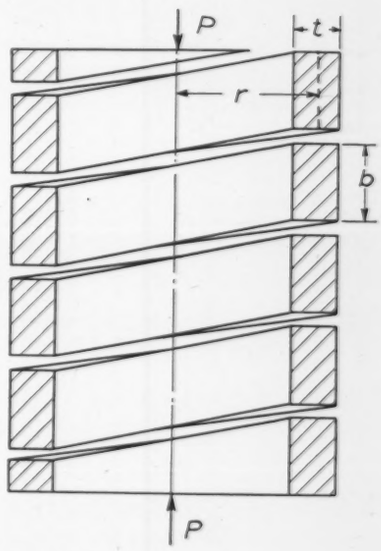


Fig. 3—Helical spring of rectangular wire axially loaded

eyebolts shown have spherical points so located that the semicoil is under a purely axial load as in the case of complete spring axially loaded. The stress could be measured with a special extensometer attached to the outside of the coil as shown. At the same time it was possible to apply an extensometer to the inside of the coil where it was found the stresses checked closely with those computed.

In order to show that the tests on the semicoils were representative of complete springs, strain measurements also were made on the outside of complete springs loaded in compression. Both square and round wire springs were tested. It was found that the stresses on the outside of the semicoils were practically the same for a given load as the stresses on the outside of the complete springs. This indicates that the semicoil test arrangement simulates the axial loading of a helical spring.

Measures Stress on Inside of Coil

It is possible by means of the arrangement shown in Figs. 2 and 4 to measure the maximum stress which occurs at the inside of the coil. It may be of interest to note that the stresses measured as in Fig. 2, on the outside of the coil, were for a given load only about 1/3 to 1/2 those found on the inside of the coil for springs having indices of three and four.

The author has worked up some comparisons of the formulas for rectangular bar springs commonly used in practice, with the fundamental

torsion formulas given by St. Venant, on which the formulas proposed in this article are based. One formula which frequently is used by spring manufacturers and users for rectangular wire spring deflection is

$$\delta = \frac{3\pi PD^3 n}{btG(b^2+t^2)} \quad \text{.....(4)}$$

with symbols as given in the foregoing. Here $D = 2r$ = mean coil diameter.

This formula may be rewritten as follows:

$$\delta = C_1 \frac{PD^3}{Gbt^3} \quad \text{.....(5)}$$

where

$$C_1 = \frac{3\pi}{1+\left(\frac{b}{t}\right)^2}$$

St. Venant's torsion formulas also may be reduced to the same form as (5) thus obtaining

$$\delta = C_2 \frac{PD^3}{Gbt^3} \quad \text{.....(6)}$$

where C_2 has the values given in Table I.

Another formula commonly given in handbooks for the deflection of rectangular wire springs is

$$\delta = \frac{2.83PD^3(b^2+t^2)}{Gb^3t^3} \quad \text{.....(7)}$$

This may be reduced to

$$\delta = C_3 \frac{PD^3}{Gbt^3}$$

where

$$C_3 = 2.83\left(1+\left(\frac{t}{b}\right)\right) \quad \text{.....(8)}$$

Values of C_1, C_2, and C_3 for different values of the ratio b/t of long to short side of the rectangular cross-section are given in Table I.

TABLE I

Values of C_1, C_2 and C_3

b/t =	1	2	4	∞
C_2 (St. Venant)	5.57	3.43	2.79	2.35
C_1	4.71	1.89	.55	0
% error of C_1....	15%	45%	80%	100%
C_3	5.66	3.54	3.01	2.83
% error of C_3....	1.5%	3%	8%	20%

Since the correct value is given by C_2 it may be seen that the values of C_1 are considerably in error and hence the formula given by Equation (4), which is commonly used, may be particularly in error, especially for values of b/t greater than 2. Values of C_3 are, however, not much in error except at large values of b/t when the error is 20 per cent.

Some spring manufacturers advocate the use of a different value of the modulus G for springs of rectangular wire than that used for calculating round wire springs. In the author's opinion, this is done to compensate for inaccuracy of formulas. There is obviously no good reason why the value of the shear modulus G should be different for a square wire spring than for a round wire spring made of the same material. However, if the formulas actually used for square wire are inaccurate then it becomes necessary to compensate for this by using a different modulus, so that the formulas agree with test

TABLE II

b/t =	1	2	4	∞
α_1	4.81	4.06	3.55	3
α_2	4.5	4.5	4.5	4.5
% error of α_2.....	6.4%	11%	27%	50%
α_3	4.25	2.68	1.46	0
% error of α_3.....	11%	34%	59%	100%

results. This is actually what is done in certain cases but it is a makeshift policy and correct formulas should be used instead.

Empirical formulas for stress in rectangular wire springs used by designers also are in considerable error for two reasons. First, they take no account of the curvature of the spring or spring index in increasing the stress. As far as test data available indicate this may be corrected for with sufficient exactitude by multiplying by the factor K as in Equation (2). Second, these formulas even for springs having large indices do not agree with the fundamental torsion formulas of St. Venant. This may be shown as follows:

From St. Venant's torsion formula the maximum stress in a rectangular bar spring may be expressed:

$$S = \alpha_1 \frac{Pr}{bt^2} \quad \text{.....(9)}$$

where α_1 depends on the ratio b/t and has the values given in Table II. In this r is the mean coil radius.

A commonly used formula for the stress in rectangular bar springs is

$$S = \alpha_2 \frac{Pr}{bt^2} \quad \text{.....(10)}$$

where α_2 has the value 4.5.

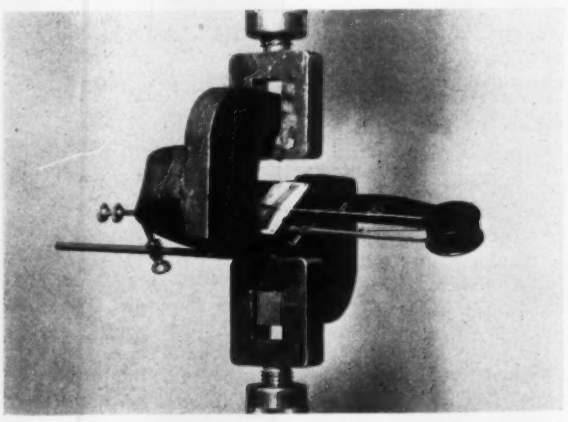


Fig. 4—Test with extensometer on inside of coil of spring

Another commonly used formula for stress in rectangular bar helical springs is

$$S = \frac{6\,Pr}{bt\ \sqrt{b^2 + t^2}} \qquad \text{.....(11)}$$

This may be written

$$S = \alpha_3 \frac{Pr}{bt^2} \qquad \text{.....(12)}$$

where

$$\alpha_3 = \frac{6}{\sqrt{1 + \left(\frac{b}{t}\right)^2}}$$

A tabulation of α_1, α_2, and α_3 is contained in Table II, together with the percentage error of each constant with respect to St. Venant's correct value, which is α_1.

An examination of this table shows that in all instances the values of α_1, α_2, and α_3, which represent the ordinary used formulas differ considerably from the correct value α_1, for at least some values of the ratio b/t. The percentage variation between α_2 and α_3, and the correct value α_1, as listed in the table gives directly the error involved in using Equations (10) and (11). It is the author's opinion that more exact formulas, such as Equations (2) and (3) which are correct to within 4 per cent for all ratios of b/t, should be used by designers instead of the equations commonly employed.

Finding Squares and Roots of Large Numbers

By B. W. Barish

METHODS of squaring large numbers and extracting square roots to many places by the aid of a slide rule and table of squares are shown by the following formulas.

(A) METHOD OF CORRECTION (not referring to table of squares).

$$\sqrt{19.'\ 41'\ 50'\ 40} = \underset{\text{Prelimin. Root}}{4.37945} + \underset{\text{Correction}}{.0268} = \underset{\text{Final Root}}{4.40625}$$

$$16$$

$$\frac{3.\quad 41\quad 50\quad 40}{9} = .37945 = \text{Prelim. decimal}$$

$$\frac{.3794 \times .6206}{8.7589} = .0268 = \text{correction} \qquad \text{.....(1)}$$

Formula (1) shows a way of finding square root by first finding a preliminary root which invariably is smaller than the final root. To find root by this method point off periods and subtract the square of the prime number of the root in the usual manner. Divide the remainder by twice the prime number plus 1, annex the thus found preliminary decimal to the prime number and mark down 4.37945 as the preliminary root; now multiply .3794 by its compliment to 1 and divide by twice the preliminary root, read off the amount of shortage, or correction .0268 on the slide rule. Add this correction to the preliminary root, and the final result will be 4.40625.

When the decimal point does not follow the first period directly we can adjust it easily in the final result. With a prime number greater than 3 this method gives results accurate to 5 or 6 places and designers will find it much quicker than the ordinary method.

(B) METHOD OF PROPORTION (using table of squares).

By the combined aid of table of squares and slide rule we can square and extract square roots rapidly and simply, and obtain results accurate to six and more places.

Let it be required to extract the square root of 318166.50. Point off periods and extract the largest root contained in the first three periods by aid of table of squares which in our example is 564.

$$\sqrt{31'\quad 81'\quad 66'.50} = 564.0625$$

$$31\quad 80\quad 96$$

$$\frac{70.50}{1129} = .0625 \text{ decimal} \qquad \text{.....(2)}$$

Subtract the square of 564, or the prime number, and divide by twice the prime number plus 1, read off the decimal .0625 on the slide rule, annex it to 564 and the result will be 564.0625.

Combining this with the method of correction as outlined in formula (1) we can get still finer results.

Squaring numbers, being a process directly reverse to that of extracting square root, is done as follows:

$$564.0625^2 = ?$$

$$564^2 = 318096$$

$$1129 \times .0625 = +\frac{70.50}{318166.50} \qquad \text{.....(3)}$$

To square 564.0625, find the square of 564, or the prime number, in the table of squares, add to it the product of twice the prime number plus 1 by the decimal .0625 performed on the slide rule and the result will be 318166.50.

Safety, Convenience, Operation Are Factors in Design

Study of the Human Element in its Relation to Design of Machines Is Receiving Increased Attention from Engineers

MICROMOTION study undoubtedly will have considerable influence on the factors referred to in the title of this contribution, as its value becomes more widely recognized. Already this type of motion analysis is being used fairly extensively in the production of small machine parts and it is predicted that its employment soon will extend to actual machine operation.

In an article prepared by R. M. Blakelock, General Electric Co., Schenectady, it is stated that micromotion is a method of job analysis employing a motion picture of the job in question, having a specially arranged clock-timing device in view

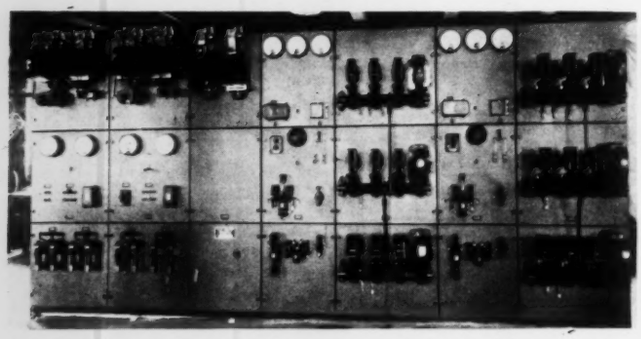


Fig. 1—Illustration of type switchboard on which exposed "live" parts were within easy reach

when the picture is taken. The clock has a hand revolving 20 revolutions per minute, and a face divided into 100 divisions. All motions made by the operator, as well as the position of the hand of the clock, are recorded by the film. Therefore by stopping the film and projecting each frame by hand any or all motions may be observed, together with the time required, accurate to within one two-thousandths of a minute. * * * As only this much generally is known about micromotion, there naturally is a widespread opinion that while the idea is unique, it is not practical for everyday job analysis. When a full knowledge of micromotion is gained, however, it readily is realized that its fundamentals and principles not only are practical but highly essential to the modern job analyst.

Applying this idea to the design of machinery, imagine the advantage an engineer connected with design would have if equipped with data provided by the results of a micromotion study of operator's motions on an earlier model machine! Mechanically, performance and many other factors would govern the redesign. From the standpoint of operative efficiency, however, in respect to production, lessening of fatigue, and the safety of the operator, he would have a fund of information available on which to base the new design.

Importance of many of the factors mentioned in the foregoing is stressed particularly in a discussion on the subject of consideration of the human element in design, by L. D. Peik, chief engineer, American Foundry Equipment Co. Inc., Mishawaka, Ind. Mr. Peik presents his views for the readers of MACHINE DESIGN, as follows:

"In the last few years the machine designer has been forced to acknowledge the value of convenience, safety and ease of operation to operators of production equipment. The writer has observed this trend, especially in the foundry forge shop and mills, where a great deal of hazardous occupation still exists.

"The three outstanding points in machine design covered in this brief discussion are convenience, safety, and ease of operation.

Convenience Often Is Overlooked

"CONVENIENCE is a factor directly affecting the operator. Attention to this point simply is not given because it may not be convenient to do a certain thing. This not only increases breakdowns through neglect, but makes the operator more discontented.

"Often it is just as easy to place a push button to control a valve by a solenoid or a hoist, as it is to have the operator climb up on the machine and reach for a lever, thus disturbing his natural posi-

tion for observing the functions necessary in production.

"Convenience also covers such items as a suitable seat, ladder with safety railing and a suitable walkway.

"Lubrication and adjustment also should be reduced to the minimum in machine design to avoid neglect. A central point of lubrication, preferably a pressure system, is of advantage. Adjustment by devices that are part of the machine, such as a handwheel, are useful items to consider.

"SAFETY has a direct bearing on noise, operator's position, fear of accident through improper guards, fear of certain shocking operations which create commotions; foolproof design which leads to interchangeability of dies and other tools, thus safeguarding against destruction of the machine.

Noise Is Detrimental to Safety

"One machine I have particular reference to is a high pressure air tank which had to be exhausted every fifteen seconds, due to the operations of the machine. At each exhaust there was an explosive-like commotion close to the operator's position. This was a great annoyance and created in the mind of the man an interruption of thought detrimental to safety. After the exhaust had been piped to a muffler to make it noiseless, the operator hardly was aware that the exhaust took place.

"The position of operator is an important one, as fear can be eliminated by provision of a protected position, giving at the same time facilities for full control. Proper lighting and clothing also are essential features to be observed by the operator and of course the machine should be built to eliminate the use of special clothing insofar as possible. In this respect I have in mind an operator in a sand blast room. It often is necessary to use high pressure on steel abrasive and the operator must be guarded against rebound by a substantial helmet, heavy clothing and special shoes. This attire is cumbersome and hinders production. On the other hand if the operator can be positioned on the outside of the blast machine seated conveniently in a clean chamber provided with sufficient fresh air, and can operate his nozzles by mechanical means, accidents can be reduced.

"EASE OF OPERATION. This subject in some cases has a direct bearing on the type of equipment purchased. In these days where piece work and other incentives for production are in vogue, ease of operation gives the operator more thought for accuracy, speed and care of equipment.

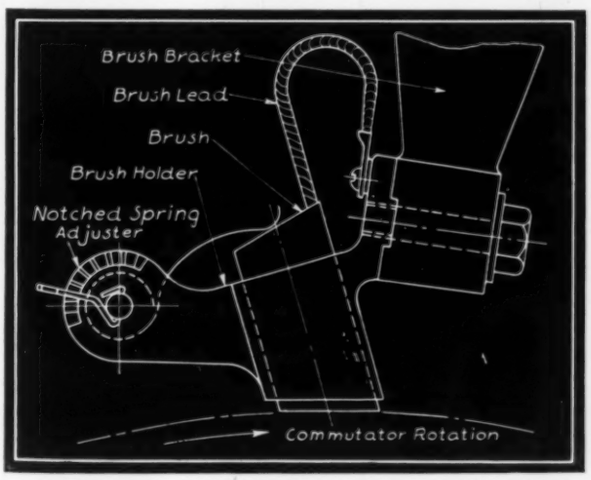


Fig. 2—Brush holder designed for convenient replacement of individual holders

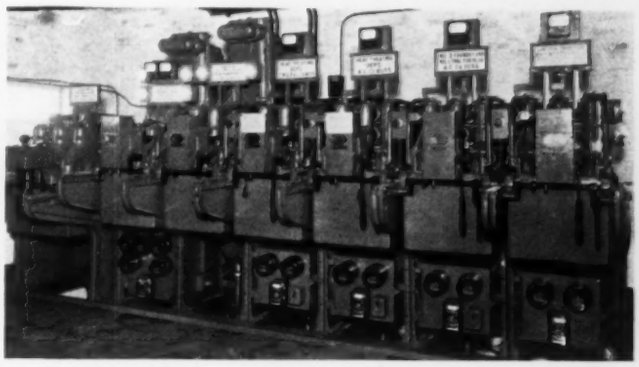


Fig. 3—New type armored switch gear showing how "live" parts are enclosed

If the designer keeps well in mind the value of using commercial parts he will save the producer a great deal of worry, because it may happen that certain parts prove inadequate or not sufficiently substantial for continuous operation. If these parts can be replaced with such items as are commercially known, replacements often are made with great pride by the user of the equipment. I know personally of certain machines produced in our own factory on which the valves sometimes stick. Our field man reported that a certain factory used an easily operated, balanced pressure valve on other equipment, and since it was interchangeable they used it on our machine, their man taking great pride in the improvement he had made. Therefore, the means provided for interchangeability of commercial parts should be constantly in mind when designing equipment.

"We also have found it of special interest to the operator to have certain parts provided with plates indicating the capacity, rating, speeds and strength of the machine."

Similar Features in Electrical Equipment

Another interesting discussion which also deals with some of the features brought out in the foregoing, has been prepared by R. W. Borchard, chief

draftsman, Allis Chalmers Mfg. Co. After stating that it is the constant aim of his company to provide machines and equipment with such conveniences and safeguards as will render them safe and as easily operated as possible, Mr. Borchard says:

"In an early article of this series mention was made of dowels. We use our own design to a great extent, provided with a nut and also a driving crown machined on the large end. The nut serves to withdraw the dowel against the friction

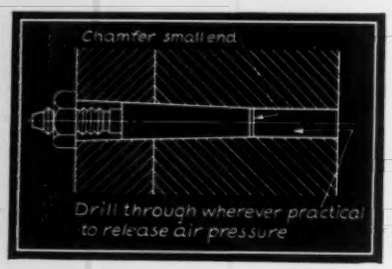


Fig. 4 — Taper dowel used on electrical machinery. Note withdrawal nut at large end. Hole is grooved if not drilled through

of its fit in the parts and the driving crown saves the thread from being battered when driving the dowel into place; both are features which not only save the operator trouble, but expedite the work and produce a much more workmanlike piece of apparatus. A drawing of one of the pins is shown in Fig. 4.

"On smaller apparatus we use standard taper pins, taking care to locate them in such positions only as will permit easy driving both in and out.

"Proceeding to larger aspects of this subject, there can be no doubt that the electrical industry generally is placing considerable stress upon this matter of "workability" of machinery. Exploring units, for example, are imbedded in windings and air ducts so that temperatures may be read conveniently, thus making exact temperature control of inaccessible parts simple and reliable. Bearings are fitted with simple spring-closed inspection covers, oil gages and high temperature alarms, all designed to relieve the operator of labor and increase the reliability of the apparatus.

Accessibility Again Is Stressed

"Brush holders can be a source of great annoyance if the pressure fingers, for example, are inaccessible to the operator. It may be essential to remove the whole brush stud containing possibly fifteen or eighteen holders in order to remove one offending holder, and then be necessary to re-assemble the whole stud and re-align it properly to get good commutation. Modern practice is to design these parts as shown in Fig. 2, so that individual holders can be removed without disturbing any other parts.

"Motor rotors now are adjustable endwise by means of suitable bearings so that the end play can be quickly and easily changed if required. These bearings also are furnished with adjusting screws to raise or lower them with great exactitude to obtain the required uniform air gap and the bearing housings are provided with easily accessible openings to permit the insertion of the air gap gage to check the gap all around.

"Starting coils are marked with white paint, leads are tagged, and wiring when complicated is arranged in various colors so that the human element may be afforded relief from needless effort in the pursuit of its tasks.

"The newest development is along the lines of safeguarding and simplifying switching equipment. The new armorclad type switchgear, shown in Fig. 3, removes the threat that is ever present in the old style switchboards with a maze of open bus bar work at the back of the board and a gleaming array of polished switches and other extremely dangerous devices on the front of the board. Men must be obtained to operate such switches and apart from crudities such as rubber gloves or an occasional wooden hook stick to operate disconnecting switches protective devices for them are pitifully few.

"With armor-clad switchgear however, a new era has begun. Nothing that carries current is exposed. A unit can be withdrawn from service

Fig. 5—Punch press equipped with specially built-in safety guard

with perfect safety for repair or adjustment. It lends itself ideally to simple and rugged interlocking and preserves the correct sequence of operation in service."

Effecting Economies in Work of Engineering Departments

By John F. Hardecker

IN CERTAIN design organizations, the product of which is highly specialized, utilization of new men becomes a distinct problem. No matter how good their previous general experience has been, there are certain intimate matters with which they are of necessity totally unfamiliar.

Therefore, for the good that might be found in the basic ideas, not necessarily applicable in full in every machine design industry, there will be presented in this article certain experiences that have been useful in meeting rushes of work—both in reducing the volume of work and in utilizing more efficiently the abilities of new men. The descriptions of necessity will be brief, with the purpose of suggesting a possibility, rather than proposing a detailed solution.

More and more, in the growing demands of industry for speedier design production, the inked tracing is being relegated to the ranks of things that used to be. The development of tracing papers, and more particularly pencil tracing cloth, has minimized the need for this costly double process. Once the draftsman masters the trick of using a softer pencil to draw full heavy lines, the problem is solved. Use of pencil tracing cloth also eliminates another difficulty not usually recognized, which is the practice of detailing a pencil layout up to a certain point and leaving the balance of "easy" detail to the tracer to insert. This "easy" detail often proves the undoing of a design, for in it on occasion lie hidden interferences not previously anticipated, which may be brought out by the tracer but which too often first see the light of day in the shop.

Materials Should Be Chosen Wisely

A bill of material often represents the anticlimax to design work. To the design itself, the choice of materials may spell the difference between success or failure. Whether the bill of material is incorporated on the drawing paper, or is issued in separate form is irrelevant as far as its real significance is concerned. The real test is whether the materials have been chosen intelligently as to physical properties, workability in the shops and availability in stores. This proper selection requires a fund of intimate technical knowledge not usually possessed by a new man, and which is particularly significant in development work. Delegation of one of the older men, preferably in the standards section, as a consultant on materials, heat treatments and finishes, is a helpful move under such circumstances. This "materials expert" should keep himself familiarized with the material available in stores, including both standard and special material, as well as such finished parts as may fall under the general classification of "hardware." If the right man is selected for this assignment, he will prove a real money saver to the organization.

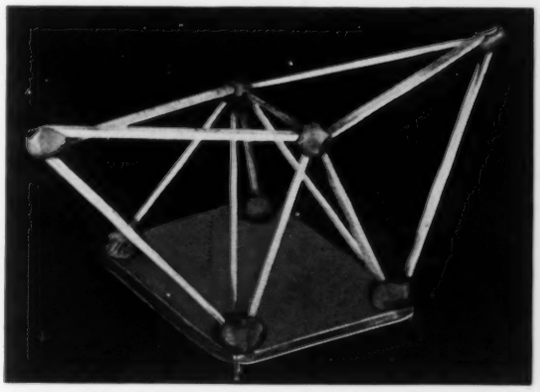


Fig. 1—Modeling clay often is useful in assisting the designer to visualize his layout

In certain fields of machine design, fittings become particularly complicated at certain points. It often is difficult for a new man, and sometimes for an older man, to visualize fully just what he is up against on a development job. Modeling clay, procurable at any art supplies store will prove helpful on occasion. In a comparatively short time the proposed fitting can be shaped up in clay, submitted for approval, and the detail proceeded with on the board with full assurance that the basic solution proposed is acceptable. In sheet metal work, similar results

can be achieved by the use of proper patterns or templates.

In actual field installations of designs, certain minor changes usually are made. If the policy of the concern or the contract under which the work is done, requires that design information on files be 100 per cent in accord with the actual installation, this may mean many trips of the designer to the field to get the required information to bring the drawings up to date. This is expensive and time consuming. The same purpose often may be accomplished by sending out a commercial photographer with the designer familiar with the job at its conclusion, and in a few hours they can take all the pictures necessary to complete the record of the actual installation. Such records are extremely valuable.

Another good practice to encourage is that of design estimating. If the personnel can be encouraged in the habit of estimating the size of a member before calculations, so that they develop a proper sense of strength values, errors, due to misplaced decimal points, wrong assumptions, etc. will be caught immediately. In addition, such personnel, on field inspection trips, may detect construction or fabrication error solely through the face that to their experienced estimating eyes a member does not look strong enough.

Far too often special designs are developed for things which can be obtained commercially. These commercial products, tools or machines not only are cheaper, but they represent designs in which the "bugs have been worked out." Of course, such conditions usually are not brought about by deliberate intent, but merely because those in charge failed to know of the existence of the commercial counterpart. This condition often can be obviated by delegating a draftsman to the task of reading all the advertisements in the technical publications which the library receives. When a new design is about to be inaugurated this "commercial draftsman" is acquainted with the desired results, so that he can check whether any commercial equipment will accomplish the same result or can be modified to suit.

Occasionally a designer is encountered who while a perfectly good man in most respects, has an over-developed sense of what he considers accuracy, but which in reality is an inability to let go of a job. He keeps adding time to his job in its final stages while he makes dead certain everything is just right. Such a man usually can be corrected by getting the actual time on some long winded drawing, converting it into costs on the basis of his hourly rate, and then armed with this data, asking him how much he would charge for a similar job on a spare time basis for a private venture. When he has named a price, or at least begun thinking of it in terms of dollars instead of hours, the mere suggestion of unfairness of the excessive cost will convey the point.

IT WILL be remembered that John H. Hardecker, chief draftsman, United States naval aircraft factory, Philadelphia, contributed to MACHINE DESIGN *a series of articles, "Organization and Supervision of Design Department," which appeared in the September to February issues. In the accompanying article Mr. Hardecker supplements his earlier contributions and gives many useful suggestions for facilitating the work of an engineering department.*

Symbols Save Time in Detailing

A great deal of time can be saved in detailing by the use of conventions or symbols—time which can be used to better advantage in the more significant phase of the design. In structural work, the symbols for field and shop rivets, round and countersunk heads, etc. have been thoroughly established, so that they are accepted practice. So are symbols for material cross sections, such as iron, steel, brass, wood, etc. In other industries, beginnings have been made, but they are not always universally accepted. In topographical drafting we have symbols for roads, railroads, bridges, cul-

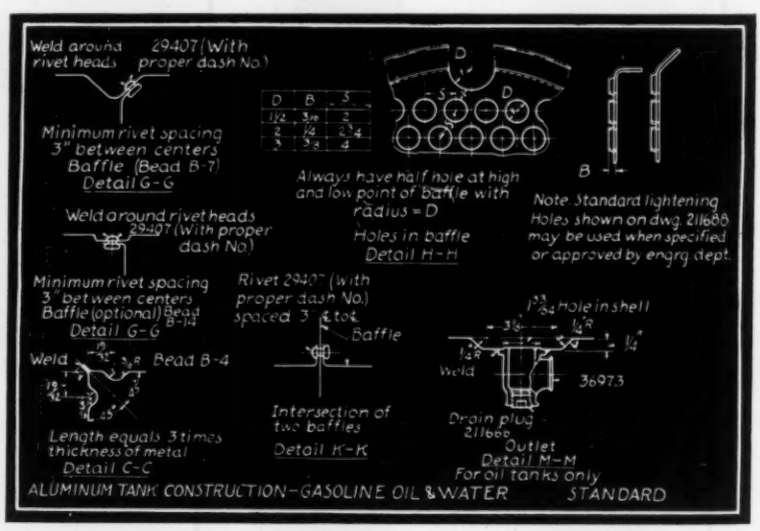

Weld around rivet heads
29407 (With proper dash No.)
Minimum rivet spacing 3" between centers
Baffle (Bead B-7)
Detail G-G
Weld around rivet heads
29407 (With proper dash No.)
Minimum rivet spacing 3" between centers
Baffle (optional) Bead B-14
Detail G-G
Weld
Bead B-4
Length equals 3 times thickness of metal
Detail C-C
Always have half hole at high and low point of baffle with radius = D
Holes in baffle
Detail H-H
Rivet 29407 (with proper dash No.) spaced 3" & tot.
Baffle
Intersection of two baffles
Detail K-K
Note. Standard lightening Holes shown on dwg. 211688 may be used when specified or approved by engrg. dept.
Hole in shell
Weld
3697.3
Drain plug 211666
Outlet
Detail M-M
For oil tanks only
ALUMINUM TANK CONSTRUCTION—GASOLINE OIL & WATER
STANDARD

Fig. 2—Type of standard drawing used to advantage where variations in size occur in similar product

verts, fences, etc., while in electrical work we have them for voltmeters, ammeters, generators, motors, switches, etc., and in piping work we have them for unions, tees, elbows, cocks, valves, etc.

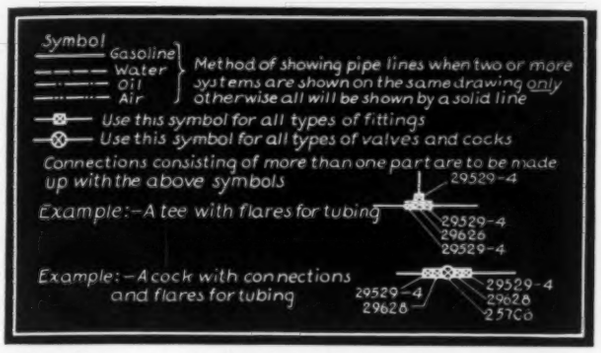

Symbol
Gasoline
Water
Oil
Air
Method of showing pipe lines when two or more systems are shown on the same drawing only otherwise all will be shown by a solid line
Use this symbol for all types of fittings
Use this symbol for all types of valves and cocks
Connections consisting of more than one part are to be made up with the above symbols
29529-4
Example:-A tee with flares for tubing
29529-4
29628
29529-4
Example:-A cock with connections and flares for tubing
29529-4
29628
29529-4
29628
2570

Fig. 3—Example of standard form showing symbols for piping

The idea can, however, be carried much farther. In any particular industry such symbols can be established and if they are included as part of the standard drawings set, they can be utilized and promulgated just as are standard drawings.

In dealing with many variations in size of a similar line of products, a great deal of the time involved in repeating similar details on each assembly drawing can be saved by the preparation of sheets of standard practice for such details. If each job ordinarily is detailed to its fullest extent, it means that slight variations as to details of construction, particularly as they involve shop practice, are bound to creep in unwittingly. These are a continual source of question and discussion by production personnel, and as practice develops, it means that all old drawings must be continually brought up to date. By using standard sheets of construction details for such assemblies as tanks, radiators, etc., it means the assembly drawing is greatly simplified and is detailed merely by reference. The standard details can be prepared in collaboration with the shops, and readily can be kept up to date. If a special detail is necessary, it is shown, and by its presence serves as a notice to the shop that the difference is necessary and not merely an oversight.

Accuracy May Eliminate Checking

Checking presents many opportunities for the applications of practical economics. In development work, it is possible to take into consideration the general reputation for accuracy of the individual designer or draftsman. If it is good, it is perfectly feasible to merely inspect his drawing and to send it to the shop otherwise unchecked. A knowledge that this procedure may at any time be applied to his drawings keeps the man on his toes and prevents his becoming careless.

On large drawings, where time is extremely limited, it sometimes is possible to use an emergency checking method that cuts down total elapsed time on the job. Instead of waiting for the drawing to be completed, and a check print struck off for checking, it is possible to check as the work progresses. As sooon as the detailing work has progressed far enough on say the left hand side of the drawing sheet, a checker is put to work with a piece of tracing paper. He places this tracing paper over the part of the job he can work on without interfering with the draftsman, and works it just as he would a check print. He often will catch an error that is repeating itself throughout the details and usually will save that precious day or two of elapsed time on the job.

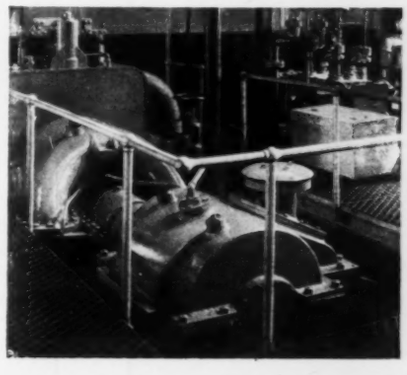
It is hoped that these hints will be found useful in facilitating the work of the designing and drafting sections of those engineering departments subject to changes in personnel and to rush orders.

Adopts Trade Code, Sales Forms

Steel Founders' Society of America Inc., has introduced its new trade customs code and standard sales forms. Their value lies in the fact that the conditions of sale are definitely outlined and policies and regulations so clearly set forth that misunderstandings will be avoided, costly delays prevented and disagreements eliminated.

Gear Case for Dredge Is Welded

A 1400 brake horse power geared turbine drive, in which the first all-welded steel gear case was used, has been installed on the American Dredging company's dredge "New Jersey" by the Westinghouse Electric & Mfg. Co. Because the all-welded construction provides a lighter and stronger gear case, it has become standard practice for dredge installations. The first all-welded steel gear case of this type fabricated is shown in the accompanying picture.



Welded steel gear case installed on a 1400 horsepower geared turbine drive

Timely Re-statement of Fundamental Mechanical Principles

By Prof. John V. Martenis, M. E.

Chief, Machine Design Division,
University of Minnesota

Gear Design—Strength of Teeth—Part II

ON OCTOBER 15, 1892, Wilfred Lewis presented to the Engineers Club of Philadelphia, a paper on the "Investigation of the Strength of Gear Teeth." In discussing the proposed method of gear tooth design, the salient points brought out in this paper covered the theory of tooth action and established the design of gear teeth upon a rational basis, which is commonly accepted as the first successful effort in this direction.

Mr. Lewis' phraseology will be followed in presenting the various arguments upon which his formula is based.

In estimating the strength of teeth, the first question to be considered is the point or line at which the load may be applied to produce the greatest bending stress. The load is sometimes assumed to be applied at the pitch line, sometimes at the end of the tooth and sometimes at one corner, but in good modern machinery, there is seldom any occasion to assume that the load is not fairly distributed across the teeth. Of course, it may be concentrated at one corner, as a result of careless alignment or defective design; however, in all cases where a reasonable amount of care is exercised in fitting, a full bearing across the teeth soon will be attained in service.

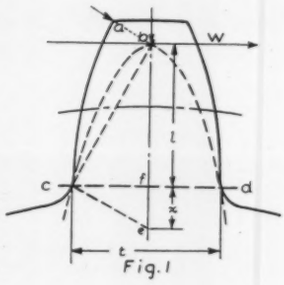


Fig. 1

Distributed Load Taken as Basis

The above assumption may not always be realized but, in general practice, where the width of the teeth is not more than two or three times the pitch, the departure cannot be regarded as serious. The conclusion therefore is reached that in first class machinery, for which the present investigation is intended, the load can properly be taken as well distributed across the tooth.

The second consideration to be determined is, at what part of the face should the load be assumed to be carried in estimating the strength of a tooth? Evidently the load may be carried at any point within the arc of action and it might be argued that when a tooth is loaded at its end, there are always two teeth in gear, and that the load should be divided between them. This is theoretically true of all teeth properly formed and spaced, but it must be admitted that mechanical perfection in forming and spacing has not yet been reached, and that the slightest deviation in either respect is sufficient to concentrate the whole load at the end of a single tooth. It is evident that the load cannot safely be assumed as concentrated at a maximum distance less than the extreme end of the tooth. In some cases the teeth will not be so severely tested and the error in this assumption compensates in a measure for the error in the assumption of equal load distribution across the teeth.

Having concluded that gear teeth may be considered as cantilevers loaded at the end, the influence of their form upon their strength must be considered. A number of figures were carefully drawn on a large scale to represent the teeth cut by a complete set of equidistant cutters, making the fillets at the root as large as possible to clear an engaging rack.

The addendum was taken 0.3 and the root 0.35 of the circular pitch. When the load is applied at the end of a tooth and normal to its face in the direction *a b*, Fig. 1, it may be resolved into two forces, one tending to crush the tooth, and the other to break it across. The radial component which tends to crush the tooth directly, has but a slight effect upon its strength. In material which is stronger in compression than in tension,

the transverse stress due to the other component, W, is partially counteracted on the tension side and the teeth are stronger by reason of their obliquity of action, but in material which is

TABLE I

Values of "y" for Use in Formula

No. of Teeth	Involute 15°	Involute 20°	Radial Flank	No. of Teeth	Involute 15°	Involute 20°	Radial Flank
12	.067	.078	.052	27	.100	.111	.064
13	.070	.083	.053	30	.102	.114	.065
14	.072	.088	.054	34	.104	.118	.066
15	.075	.092	.055	38	.107	.122	.067
16	.077	.094	.056	43	.110	.126	.068
17	.080	.096	.057	50	.112	.130	.069
18	.083	.098	.058	60	.114	.134	.070
19	.087	.100	.059	75	.116	.138	.071
20	.090	.102	.060	100	.118	.142	.072
21	.092	.104	.061	150	.120	.146	.073
23	.094	.106	.062	300	.122	.150	.074
25	.097	.108	.063	RACK	.124	.154	.075

Values for cycloidal gears, same as 15° involute.

weaker in compression, the reverse is the case. In general the strength of the teeth will not be affected more than ten per cent either way by the consideration of this radial component.

For the sake of simplicity, the factors given have been determined only with reference to the transverse stress induced by the force, W, which may be regarded as the working load transmitted by the teeth. This load is applied at the point b, but it is not apparent where the tooth is weakest. To determine that point, advantage is taken of the fact that any parabola in the axis $b\,e$ and tangent to $b\,W$ at the point b encloses a beam of uniform strength, (see Fig. 1). Of all the parabolas that thus may be drawn, one will be tangent to the tooth form and it is evident that the point of tangency will indicate the weakest section of the tooth. The weakest section $c\,d$ may be found tentatively to a nice degree of accuracy in two or three trials.

Graphical Solution Is Possible

The strength at the weakest section also may be determined graphically by drawing $b\,c$ and erecting the perpendicular $c\,e$ to intersect the center line of the tooth in e. Then $e\,f$ or x is taken to measure the strength of the various forms of teeth. To understand the reason for this construction and the actual relation which the distance x bears to the strength of the tooth, it will be observed that the bending moment $W\,l$ on the section $c\,d$ is resisted by the fiber stress S times 1/6 the face b times the square of the thickness t, or $W\,l = 1/6\ S\,b\,t^2$ or

$$W = \frac{S\,b\,t^2}{6\,l}$$

In the triangle $b\,c\,e$, $e\,f\ :\ c\,f\ ::\ c\,f\ :\ f\,b$ or $x : t/2 :: t/2 : l$, $\therefore\ t^2 = 4 \times l$. Sustituting these values in the previous expression,

$$W = \frac{S\,b\,4\,x}{6}$$

which may be written,

$$W = S\,b\,p'\left(\frac{2\,x}{3\,p'}\right)$$

or $W = S\,b\,p'\,y$ in which $2x/3p' = y$, a factor determined by graphical construction and given in Table I.

Table II, covering "y" values for the Fellows system of gearing, is taken from Leutwiler's *Machine Design*.

Allowable Working Stresses

What fiber stress is allowable under different circumstances and conditions cannot be definitely settled nor will any conclusions be acceptable to engineers unless based upon carefully made experiments.

The working stresses submitted in Table III have given good results for a number of years in machine design. When the durability of a train of gearing is considered, it would seem that all gears in the train should have the same pitch and face. But equal wear does not mean equal life in a train of gearing and a compromise between the considerations of life and strength must result in the adoption of values for different speeds.

TABLE II

Lewis Factor "y" (Fellows System)

No. of Teeth	Gear Pitches 4/5	5/7	6/8	7/9	8/10	9/11	10/12	12/14
12	.096	.111	.102	.100	.096	.0100	.093	.092
14	.105	.119	.112	.111	.106	.108	.102	.100
16	.111	.126	.119	.118	.113	.114	.109	.106
18	.117	.131	.124	.124	.119	.119	.114	.111
20	.121	.135	.129	.129	.124	.123	.118	.115
22	.125	.139	.133	.133	.128	.126	.122	.118
24	.128	.142	.136	.136	.131	.129	.125	.121
26	.130	.145	.139	.139	.134	.132	.128	.124
28	.133	.147	.141	.141	.136	.134	.130	.126
30	.135	.149	.143	.144	.138	.136	.132	.128
35	.139	.153	.147	.148	.143	.139	.136	.132
40	.142	.156	.151	.151	.146	.142	.140	.135
50	.147	.161	.156	.156	.151	.147	.144	.140
60	.150	.164	.159	.159	.154	.150	.148	.143
80	.155	.168	.163	.163	.158	.154	.152	.147
100	.158	.171	.166	.166	.160	.156	.154	.150
200	.164	.176	.172	.171	.166	.162	.160	.156
Rack	.173	.184	.179	.176	.172	.170	.168	.166

Since the time the stresses in Table III were proposed, other materials have been brought into use for gear construction. Beside the metals, rawhide, cloth and fiber are commonly used, especially for quietness and smooth running.

Carl Barth proposed a formula to determine stresses to be used in gear design, of the following form,

$$S = \left(\frac{600}{600 + V}\right) S_o$$

in which V = pitch line velocity in feet per min-

ute; S_o = safe working stress when $V = O$. Stress values S_o are shown in Table IV.

TABLE III

Safe Working Stresses (Lewis Formula)

Material	Speed in Feet Per Minute							
	100	200	300	600	900	1,200	1,800	2,400
Cast iron....	8,000	6,000	4,800	4,000	3,000	2,400	2,000	1,700
Steel	20,000	15,000	12,000	10,000	7,500	6,000	5,000	4,300

Formula Used for Bevel Gears

In teeth of the involute and cycloidal forms, there is a marked difference between racks and pinions in working strength, while in radial flanked teeth which are used more especially on bevel gears, the difference is not so pronounced. These teeth are to be found in the great majority of all cut bevels because of cheapness of production. To bring the strength of bevel gearing within the scope of this investigation, it will be necessary to understand how the variation in pitch and the radius of action is allowed for. Referring to Fig. 2,

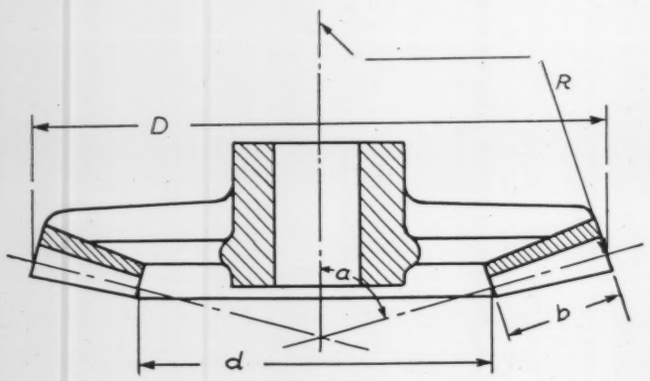


Fig. 2

D = large diameter of bevel
d = small diameter of bevel
p′ = pitch (circular) at large diameter
n = actual number of teeth
N = formative number of teeth
b = face of bevel tooth
y = factor depending upon shape of teeth and formative number N
W = working load on teeth

Then, it can be shown,

$$W = S\,p'\,b\,y\,\frac{D^2 - d^2}{3\,D^2\,(D-d)}$$

This formula can be greatly simplified if d is made 2/3 D, in which case the approximate formula, $W = S\,p'\,b\,y\,d/D$, can be used with satisfaction. The reason for fixing a limit to the ratio d/D is found in the fact that a further increase in the face adds but little to the strength and increases the difficulty of distributing the pressure transmitted.

There are many cases involving the determination of the circular pitch p' of a gear to transmit a given horsepower at a required angular velocity or number of revolutions per minute. In such cases the diameter of one gear must be known or assumed in order to find the linear velocity V, of the pitch line. The tooth pressure or load usually is found from the torque formula developed in a former article in MACHINE DESIGN, namely, $P\,R = 63025\ H.P. \div N$. The load thus found is tangential at the pitch point of the gear and can be used in the formula provided the obtainable circular pitch p' is taken not less than the computed value.

Since meshing gears usually differ in diameter, the formula must be applied to the smaller gear if both gears are of the same material, otherwise it may be necessary to check the stress in the larger gear if it is of inferior material.

TABLE IV

Stress Values S_o (Barth Formula)

Material	S_o	Material	S_o
Alloy Steels, hardened.....	100,000	Semisteel	15,000
Alloy Steels, case hardened	50,000	Cast Iron	8,000
Machine Steel	25,000	Rawhide	8,000
Cast Steel	20,000	Fabroil	8,000
Bronze	12,000	Bakelite	8,000

It is evident from the formula that the width of tooth face effects the circular pitch p', therefore an increased width of face will reduce the required pitch p' to transmit a given load.

Should a wide face gear be permissible, helical cut teeth will conduce to smooth running.

In the design of gears subject to continuous running, the element of durability in many cases will be of greater importance than that of strength and this condition can be met by using moderate stress values or better materials.

Develops New Synthetic Substance

A new synthetic resin known as "Durium" and transformed by heat from a liquid to an insoluble, infusible, flexible solid recently was perfected by Dr. H. T. Beans, of Columbia university, New York.

A thin film of Durium, it is claimed, will not crack or chip under hammering, yet is almost as flexible as paper. Besides withstanding the temperature of molten lead or type metal without change, the new material, at excessively high temperatures, oxidizes without melting. Durium differs chiefly from other synthetic resins in that it hardens quickly, making it possible to utilize stamping instead of molding processes which consume more time.

Incorporating Variable Transmissions in Machines

By D. W. Clem

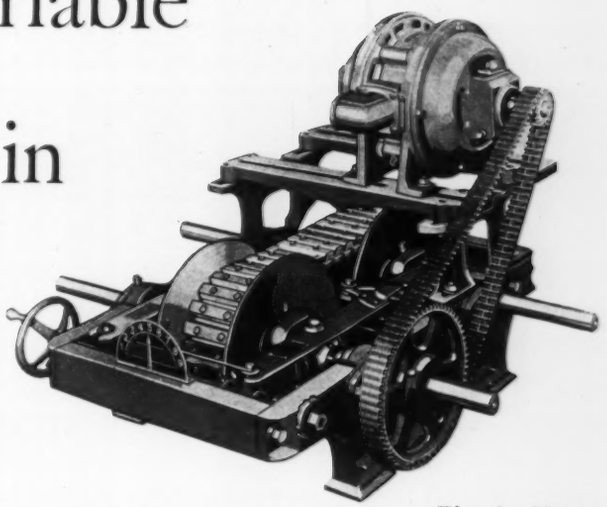


Fig. 2—Motor may be mounted directly above transmission to provide combined unit

VARIABLE speed control has a definite place in modern production. The manufacturer who can regulate his machines and processes to the demands of constantly changing factors, can produce the greatest volume of quality product. Fluctuations in temperature, variation in quality of material in process, change in shape or size, change in operation or time, number of workmen available, different degrees of human ability, change in tension, shrinkage, stretch or consistency of material, varying climatic and operating conditions or changes in humidity, varying production schedules—these and other constantly changing production factors demand an infinite number of adjustments in the speed of a machine in order to operate at highest efficiency. There is one best speed for every machine under different operating conditions and as the conditions vary, so must the speed of the machine.

For this reason machinery and conveyor manufacturers should not leave to their customers the problem of power and speed regulation, as was the custom a few years ago. It is to the machinery manufacturer's interest to furnish his machinery complete, ready to run; or better still, in operation. When power transmission and speed control problems are left to the customer, he feels that the manufacturer of the equipment is interested only in the immediate sale of the machine and not in the future efficient production and operation of the unit.

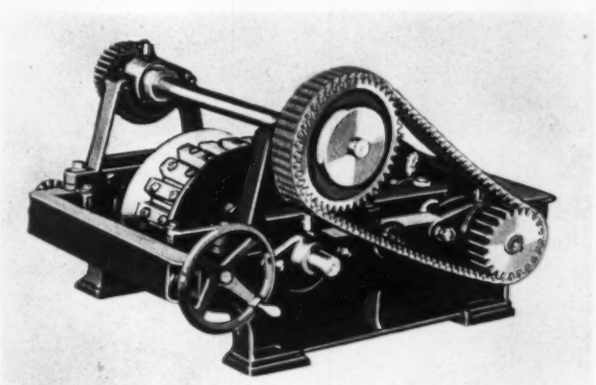


Fig. 1—Obtaining large reduction by means of countershaft built onto the transmission

Variable Speeds Offer Advantage

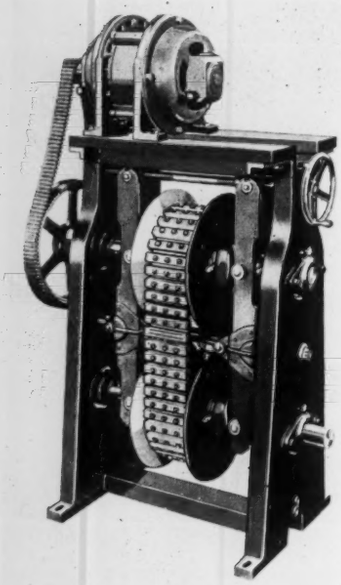
By equipping his unit for infinite speed control, with the modern built-in or attached variable speed transmission, the machine manufacturer increases his sales arguments and advantages over competitors who have single speed machines or machines adjustable in only a few speed steps. It gives him greater sales leadership, as well as broadened fields of application. This means added effectiveness to the sales organization.

For instance, a great many pastry baking ovens today are provided to give infinite baking times from 2½ minutes to 100 minutes; such ovens take the thinnest wafers for the short bake and all types of product at any fractional intermediate baking period up to and including pound cake at the longest baking period. This ability to regulate the speed quickly, easily and accurately makes it a general purpose oven. The manufacturer of this oven has extended his sales fields, as the oven appeals to the plant baking the general line. Such plants would not install several ovens to take care of their requirements—they would no doubt drop some of their products if they could not handle them on a single oven.

The builders of a line of heat treating furnaces

formerly equipped their units for one fixed speed. This limited their furnaces for the particular material to be treated. Of necessity, they had to do much research work on each proposal in order to furnish a furnace that operated at the correct speed. They now have equipped their line of furnaces for speed regulation, making them suitable for handling pieces from needles to armor plate bolts and rivets.

These cases are only two of many instances which could be cited where production machines have been made more universal, and possess greater utility value by equipping them with some method of flexible speed regulation and control.



The mechanical variable speed transmission shown in the accompanying illustrations is one of the most outstanding methods of securing infinite speed regulation. Transmissions are built in sixteen sizes, covering capacities from fractional to 150 horsepower, and giving ranges in speed adjustability from 2:1 to and including 16:1 ratios, or maximum and minimum limits.

Fig. 3—(Left)—Vertical unit for use where floor space is limiting factor. Fig. 4—(Right)—Three transmissions built into cake machine for feed, cutoff and discharge

Laboratory tests and installation tests under working conditions in the field have shown that the modern type of variable speed transmission has an average efficiency rating of over 95 per cent peak. This rating means the practical absence of friction which makes for accuracy in operation, long life and low up-keep expense. All operating and wearing parts float on heavy-duty ball bearings.

Various Drives May Be Used

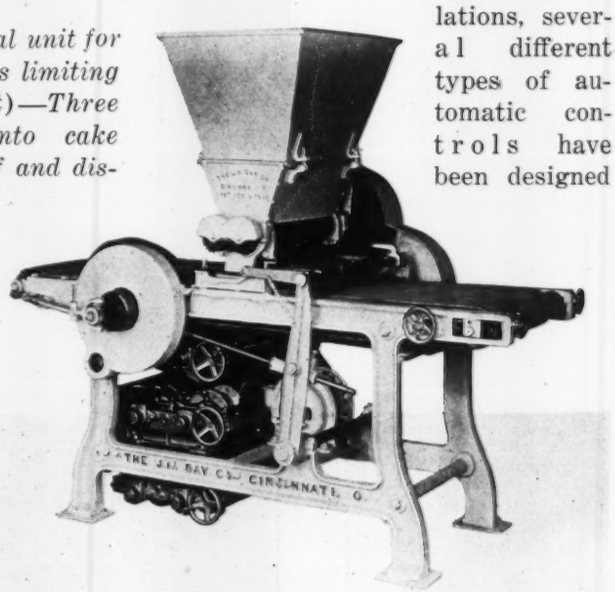
These transmissions are furnished of the type known as individual variable speed power units (see Fig. 2) wherein the power motor, usually high speed, is mounted immediately above the transmission on a rigid, universally adjustable motor base. The drive between motor and constant shaft may be silent chain, gears, V-belt, pulleys and belt, etc. This unit, equipped with incorporated countershaft, (Fig. I), will give a speed reduction as high as 50:1.

The floor space occupied is the same as for the transmission alone, and the units may be set on the floor, suspended from the ceiling, placed on platform or stand, or incorporated in the driven machine.

Motor Is Mounted on Unit

Where minimum floor space is available, vertical transmissions, as shown in Fig. 3, are furnished. On these the power motor is mounted on top of the transmission on a universally adjustable base. This vertical unit also is regularly fitted with incorporated countershaft for speed reduction. Minimum floor space as well as least cubic space is taken by this type of unit.

Where the transmission is located at a considerable distance from the control point, as is often the case, the unit is fitted with remote mechanical or remote electrical control, as illustrated in Fig. 5. By merely pushing a button or pulling a cable the speed of the driven machine may be adjusted from any point in the plant. Also, for certain special installations, several different types of automatic controls have been designed to eliminate the need for an operator of the unit.



On this unit a fractional horsepower reversible motor, for any current characteristic, is mounted on a bracket above the speed changing screw and is connected to it by double spur gear reduction. This motor can be started in either direction by one or more push button stations. The pilot motor is fitted with solenoid brake, which engages the instant the push button is released, holding any desired speed indefinitely.

Variable speed transmissions also are furnished as standard for automatic mechanical or automatic electrical control. The use of automatic equip-

ment to reduce labor costs and insure a uniform product is becoming more and more universal in the manufacturing world, and this unit eliminates the operator and regulates the machine automatically.

In a great many processes it is necessary to have two or more production machines in range or line, or as dictated by most efficient plant layout. It also may be necessary that the units be kept in synchronization, especially in textile plants. This easily is possible with the automatic mechanical or automatic electrical units, keeping in step with such variables as temperature, weight, time, humidity, speeds, etc. These automatic units have an ideal application in driving center drive windups for rope cloth, wire, paper, cable, etc., maintaining constant travel in feet per minute of material with constantly increasing diameter. They also are employed for maintaining the same peripheral speed on cylindrical stock constantly reducing in diameter.

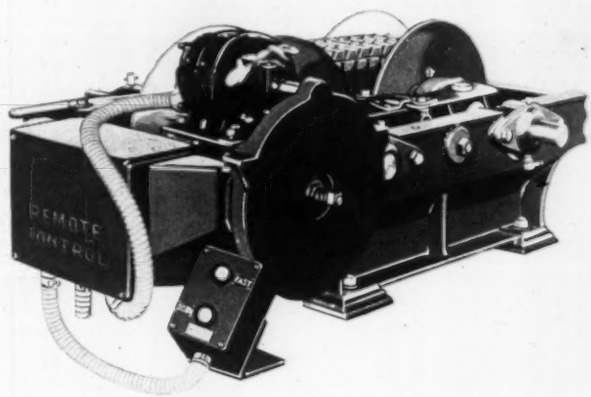


Fig. 5—Unit equipped with remote control

Automatic units often are applied to maintain a certain constant speed and to compensate for voltage change in the line, or fluctuation in the source of power,.

All the foregoing and other types of standard transmissions are furnished totally enclosed and of various designs to meet the exact requirements under which they are to operate. Each transmission is fitted with dial-type speed indicator to show the exact speeds at all operating positions.

Advantages of this type of speed transmission, summarized, are:

1. Infinite number of speeds is available.
2. Transmission of power is positive at all speeds, and when a unit of correct capacity is installed there is no slippage, except where sudden shock overload is applied. Slippage then acts as safety valve, preventing serious injury or damage to other equipment to which unit is connected.
3. When set, speed remains constant until again changed. Speed does not fluctuate with variations in load.
4. Power consumption is directly proportionate to the speeds.
5. Speeds may be changed while driven machine is running.
6. Wide ratio of variation is available—16:1.
7. High efficiency—reaching 98.6 per cent peak.
8. Automatically locks in speed at desired setting.
9. Due to complete ball bearing equipment and force feed lubrication system, requires minimum maintenance.

In the design of a new machine it is an easy matter to incorporate the variable speed transmission entirely, or the internal operating parts, in the machine designed. On new units, the designing engineer who is interested would do well to consult the manufacturers of the transmissions because what may seem to demand a special design or application for a given service may prove to be regular and standard in every way. Investigation shows that the transmission manufacturers already have taken into consideration almost every conceivable type of problem that could confront the machinery builder, and have designed numerous types of unit to meet the varied requirements satisfactorily. Those illustrated and described in the foregoing cover only a small percentage of the complete line.

New Castings Directory Published

Complete and up-to-date data fill 170 pages of a booklet just issued and entitled "1930 Directory of Manufacturers, Steel Castings, Heat and Corrosion Resisting Castings in the United States and Canada," according to an announcement by Steel Founders' Society of America Inc. It gives the capacity, equipment, production data for 260 foundries in the United States and 17 foundries in Canada. Summaries and statistical charts in the back of the book give a quick picture of various classifications in detail and total. Altogether, this directory is the most complete ever issued on the steel casting industry and is a valuable reference book for those interested in the industry.

Copies of the section of the directory which is devoted to statistics will be sent on request to the Steel Founders' Society of America Inc., 932 Graybar Bldg., 420 Lexington avenue, New York.

New Material Offers Many Possibilities to Designers

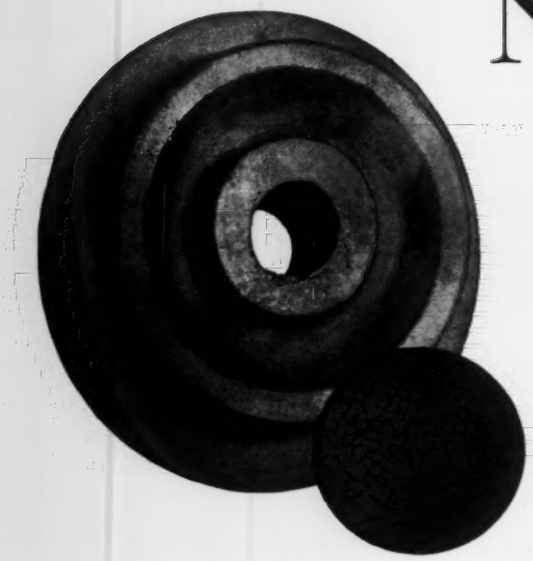


Fig. 1—Casting and microphotograph of Meehanite showing grain structure

INTRODUCTION of a new material into the mechanical industry is commanding interest, particularly of designers, by virtue of its possibilities in aiding them in meeting problems which constantly arise in the development of machines.

With castings one of the primary factors on which the engineer builds it is not surprising to note that more and more effort has been expended to produce an iron which will meet new requirements and still maintain a liberal amount of versatility. This new material is known as "Meehanite" and was developed by G. F. Meehan.

According to claims it possesses most of the qualities of carbon steel. Casting and machining properties are similar to those of ordinary cast iron, and it offers great resistance to corrosion. It also is particularly useful for castings where non-porosity, resistance to wear and increased strength are principal considerations. Reduced weight of individual parts is an outstanding feature in its application.

Structure and Grain Size Uniform

Meehanite metal is an iron with a close grain, having a pearlitic body wherein the graphite is distributed in nodules and in more numerous, smaller flakes than are found in gray iron. As can be seen in Fig. 1, a microphotograph of the material, there is absence of segregation and uniformity of structure and grain size. The structure is similar to that of fine steel though castings produced from it have the appearance of gray iron. Results of the Stanton test show a value of 2700. This homogeneous structure provides considerable resistance to corrosion and oxidation under certain kinds of working conditions.

Specimens of about 0.5-inch in diameter over a gage length of 2 inches which have been submitted to the bureau of standards at Washington, for testing to determine tensile strength show favorable results. Data yielded by the tests are shown in Table II. In the brinell hardness test a load of 3000 kilograms was used.

Tensile strength of the new metal may be varied from 45,000 to 50,000 pounds per square inch by changes in composition and manufacture but it also is being produced by heat treatment, with a tensile strength that frequently runs higher than this. Two per cent elongation is not unusual. A standard specimen under the transverse test will withstand a central load varying from 5500 to 8000 pounds before fracture. Along with this the deflection rarely is lower than 0.16-inch and frequently as high as 0.20-inch.

In analysis the metal varies to meet specific requirements. High steel scrap additions running

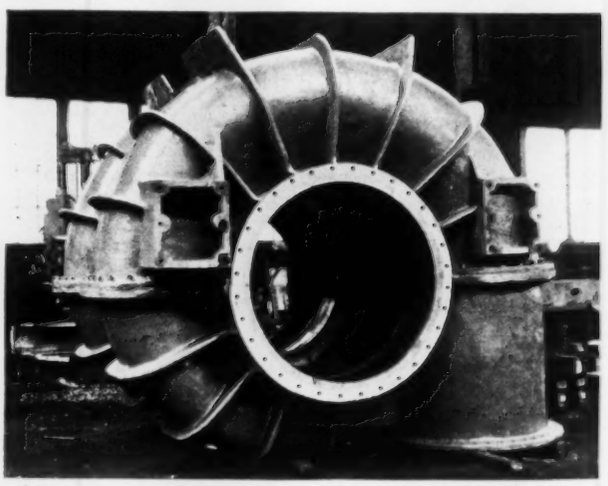


Fig. 2—Centrifugal pump casing measuring 48 inches and cast in two parts

as much as 86 per cent form the raw material for the cupola charges. The standing it holds in respect to specific gravity is shown by the value 7.49. It is so low in total carbon and silicon that normally a casting poured from it would be hard; however, the processing graphitizes sufficient carbon and breaks down the hard iron carbides. Approximate composition of the material is shown in Table I.

TABLE I

Composition of "Meehanite"

Carbon	2.40-2.70
Silicon	1.10-1.50
Manganese	0.65-1.00
Sulphur	0.05-0.14
Phosphorus	0.10-0.20

Meehanite is claimed to machine more easily for the same resistance than any other iron. It gives off in turning little curls like steel, revealing its tenacity. Because uniform sections can be cast it has been found unnecessary to allow much excess metal for machining.

Heat treating is comparatively simple and may be done by holding the temperature at 1650 degrees Fahr. for some time and cooling in air. This gives it a tensile strength upwards of 75,000 pounds per square inch, an elongation of 1.5 per cent and a brinnel of 230. Heated to 1650 degrees Fahr. and cooled not faster than 10 degrees per hour, it has a tensile strength of 45,000 pounds, and an elongation of 4 per cent. Heated to 1150 degrees Fahr., quenched in oil and drawn to 1450 degrees Fahr., it has a tensile strength of over 85,000 pounds, a brinnel of 250, but no elongation or reduction of area.

Because of the almost entirely pearlitic matrix the only necessary steps in heat treatment are to raise the metal to a red heat and quench to chill the surface. Treatment is governed by the hardness desired and it is possible to obtain one surface hard and another soft through a local heat treatment followed by a quench. By casting the surface to be hardened against a chill, the same hardening effect can be obtained. Reheating to a dull red and permiting it to cool softens the casting.

In the automotive industry preliminary tests indicate that Meehanite is likely to prove a superior material in many instances. Heat treated, it stands up remarkably in valve tappets and also is suitable for valve guides and push rod guides. Because of its tensile strength the material is desirable as flywheel material, particularly since higher speeds have been introduced. Another case where it is successfully used is for camshaft gears on truck engines. Its properties, particularly in respect to its ability to withstand high temperature without loss in strength, have made possible the manufacture of Meehanite pistons which are much lighter than those produced from ordinary gray iron.

Since the development of the new material designers have found it has a wide range of usefulness. Its even density regardless of the metal section makes it particularly valuable for gears. When cast properly it will be found that the metal is as sound in the root of the tooth as it is on the outside. Numerous other uses include parts for refrigerators and internal combustion engines, mining machinery, blast furnace construction, steel mill equipment, valves, pressure castings, pump bodies, cut gears and pinions, coupling castings, cams and dies.

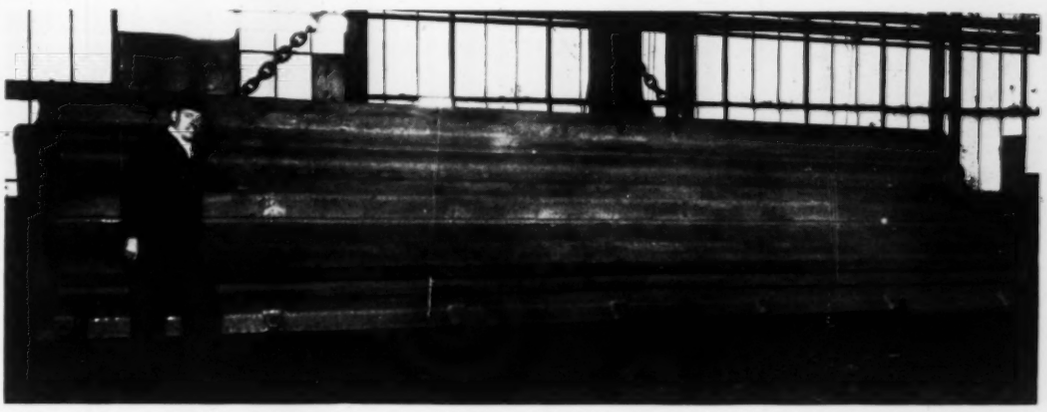


Fig. 3—Horizontal boring mill table. This large casting weighs 30,200 pounds

TABLE II

Properties of "Meehanite" metal

Diameter in inches	Tensile Strength lb. sq. in.	Reduction of Area per cent	Elongation in. 2 in. per cent	Brinell hardness number
0.500	45300	0.0	*	262
0.498	54800	0.0	1.0	304
0.498	49500	0.0	1.0	279
0.500	53100	0.0	0.0	279
0.500	56500	0.0	0.0	295
0.500	46600	0.0	0.0	297
0.498	52300	0.0	0.0	324
0.500	45800	0.0	1.0	269
0.499	56200	0.0	1.0	300
0.499	45300	0.0	0.0	282

Castings shown in the accompanying illustra-

tions were made by the Fulton Foundry & Machine Co., Cleveland, a licensee of the Meehanite Metal Corp. Ross-Meehan Foundries, Chattanooga, Tenn., a concern specializing in large castings, originally produced the new material. Now other foundries have been licensed under the Meehan patents. The material does not demand special equipment but it does require close supervision.

On such machine parts as beds, work tables, slides and gibs it is possible to obtain increased strength without redesign, a factor of importance in industry. When it is considered that Meehanite can be cast in the thinnest and thickest sections

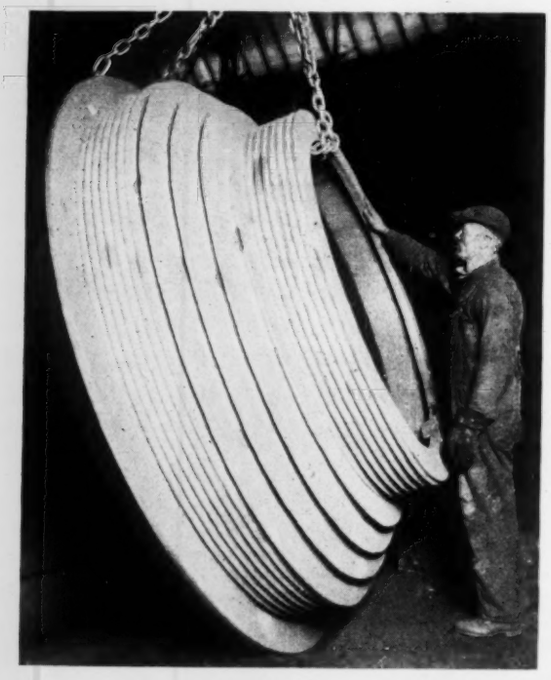


Fig. 4—Mine hoist drum showing cable grooves which were swept in mold. Machining was unnecessary

with the same hardness of structure, is capable of being heat treated like steel, may be as soft as malleable iron or harder than chilled cast iron, it will be apparent to the designer that the new material has excellent possibilities.

Results of tests on spring steels, phosphor bronze and hard-drawn aluminum wire indicate that the elastic limit and proportional limit do not coincide, according to M. F. Sayre, Union college, Schenectady, N. Y., who presented a paper on that subject at the recent meeting of the American Society for Testing Materials at Atlantic City. A comprehensive survey of the present knowledge of fatigue of metals as presented in the world's technical literature will be published shortly by the society, it was announced by Prof. H. F. Moore, University of Illinois, chairman of the research committee.

Notable Business Journal Renamed "Steel"

THE PENTON PUBLISHING CO., which is affiliated with the Johnson Publishing Co., publisher of MACHINE DESIGN, announces that beginning with the July 3 issue, *Iron Trade Review,* which has served the steel industry for 48 years under that title, becomes *"Steel."* The new name has been adopted because it defines the scope and purpose of the publication more accurately.

Concurrent with the change in title, the format, arrangement of editorial and advertising pages, typography and other physical characteristics of the publication have been improved decidedly to comprise an unusually attractive publication.

More emphasis is put on news articles and information of greatest interest to the largest number of readers. A digest enables the busy executive with only a few minutes at his disposal to "high spot" the week in steel. Greater opportunity is afforded for presenting and interpreting major news items effectively.

The section devoted to the Business Trend is made more graphic through the use of color. Market reports are presented in more legible form and prices are quoted in larger type. *Steel* also presents a comprehensive digest of all significant activities in the technical operations of the steel industry, in addition to its usual articles on engineering practice in the various departments.

To stimulate the preparation of better advertisements and to enable readers to derive the fullest values from advertising pages, advertising and editorial pages have been regrouped. The new make-up is advantageous to readers and advertisers alike.

No change is made in the editorial policies which have carried *Iron Trade Review* from obscurity to a position of high rank in business paper publishing. To *Steel* is afforded greater freedom of action and increased opportunities for editorial evaluation and interpretation. In every respect the publication is more closely attuned to swiftly moving events in the steel industry.

With *"Steel"* on the masthead augmented by exploitation of the material throughout the editorial pages, the course of the publication is charted definitely. Its purpose will be to create an informed leadership among the rank and file of the industry, to facilitate the exchange of useful information on business, economic and technical matters, and to support all constructive movements affecting steel.

How Interchangeability of Parts Reduces Upkeep Cost

By E. J. Hall

Fig. 2—Oil filter developed for engine

IN DESIGNING the Hall-Scott 4¼ x 5½-inch six-cylinder motorcoach engine, the primary aim was to design it so that the regularly recurring maintenance operations would come in groups and the operator could systematize his shopwork, all units would be interchangeable, any operation could be completed by a trained crew in a maximum time of 2 hours, and practically no occasion would arise for removal of the engine from the chassis except for work on the main bearings of engine and for crankshaft regrinding.

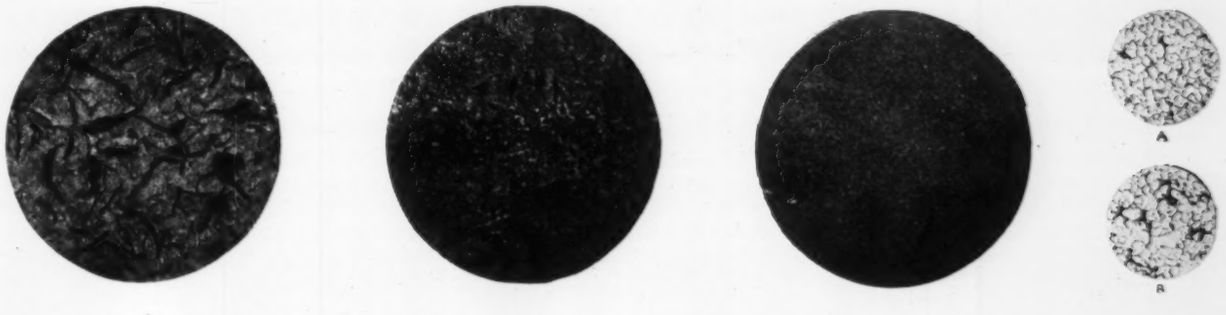
The cylinder-head is a complete unit containing the valves, camshaft, rockerarm shaft and governor, and is interchangeable on all engines of a given series. By carrying an extra cylinder-head assembly in stock, the owner of a fleet of motorcoaches using these engines can handle all valve grinding leisurely. Two mechanics can remove a cylinder-head and replace it by a reconditioned head in about an hour.

CAREFUL selection of materials and interchangeability of parts are primary factors in reducing maintenance costs, as brought out forcibly in the accompanying abstract of a paper on engine design presented by E. J. Hall at a meeting of the northern Californian section of the Society of Automotive Engineers.

Interchangeability also is a feature of the cylinder block, shown in Fig. 4. This is made as simple as possible so that, in servicing, a worn block can be replaced by a new one and the old block reground later. As this block is simple and inexpensive, it is about as cheap to scrap the old block and substitute a new one as to grind the cylinders in an old block.

The ideas governing the design of the block were to have no bosses attached to the cylinder barrel and thus eliminate stress and distortion due to nonuniformity of cylinder wall thickness; to have the studs (of nickel-chromium steel) which hold the crankcase, cylinder block and cylinder head together, extend entirely through the block so that there would be no strain on the cylinder barrels on account of uneven pressure from this source; and to eliminate all valves and other expensive parts which would be thrown away if the block were scrapped. The block can be produced inexpensively and, since it is merely clamped between the cylinder head and the crankcase, its removal is accom-

Fig. 1—Grain structure of materials employed (Left)—Semisteel, formerly used in cylinder head. (Center)—Nickel chromium cast iron which replaced the semisteel. (Right)—Heat treated nickel chromium steel for crankshaft. (A and B)—Bearing materials



plished easily. Nickel chromium is used for the block.

Lubrication is important in this type of engine. Splash feed was not suitable because the original viscosity of the oil for a splash-feed type engine is too low to provide a sufficient margin of safety from dilution by fuel or thinning out due to heat, and on a motor-coach engine it is important to be able to use an oil-filter; therefore the engine was designed to operate with force-feed lubrication. We use a conventional oil sump provided with a strainer, and an oil pump located on the front of the crankcase where it is easily removable as a unit.

Oil Filters Through Felt Disks

Fig. 1 shows the oil filter, composed of felt disks held together under pressure. Oil enters the outside casing from the pump, which forces it through the edge grain of the felt disk and thence to the engine bearings. This felt becomes stopped-up in time, but the filter actually works better as the carbon starts to build up on the outside of the felt cartridge. The carbon, being porous, offers no resistance to the oil under normal conditions, and the filter ceases to function normally only when the space between the felt and the outer casing becomes completely filled. The filter should be cleaned out before this condition is reached; but, to guard against neglect, a small by-pass valve set to operate at a pressure of 3 pounds per square inch is provided.

We do not increase the size of our motorcoach crankshafts because there is a limit to the peripheral speed at which crankshaft bearings should

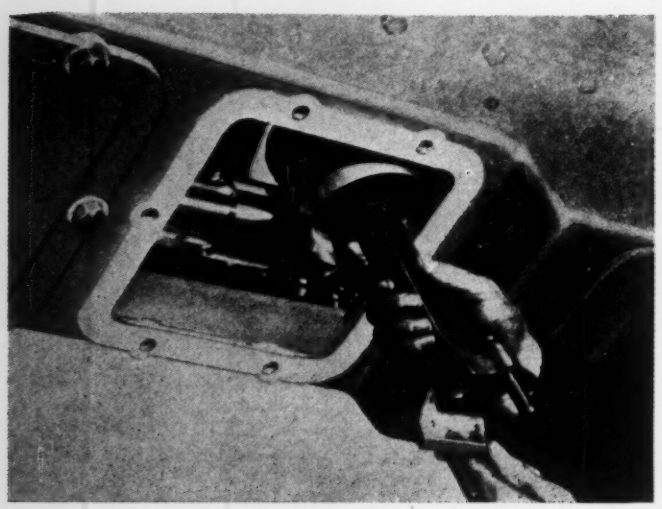


Fig. 3—Hand holes are provided for insertion or removal of pistons and connecting rods

be operated. After studying the matter closely, we find several difficulties inherent in the shaft, the principal one being the distortion due to centrifugal force. Unless a large crankshaft is counterbalanced, one cannot build a crankcase that will hold it under operating conditions and severe service is imposed on the bearings. If counterbalances are used, they increase the service cost as well as the total weight, and to carry extra weight is costly. So, as we analyze it, the only thing achieved by using a larger crankshaft is extra expense. We, therefore, use a better material and provide sufficient bearing area while limiting the size. A microphotograph of the material is shown at the right of Fig. 1.

The connecting rod is of nickel-chromium steel, heat treated to give extremely high physical properties, and experience dictates certain features

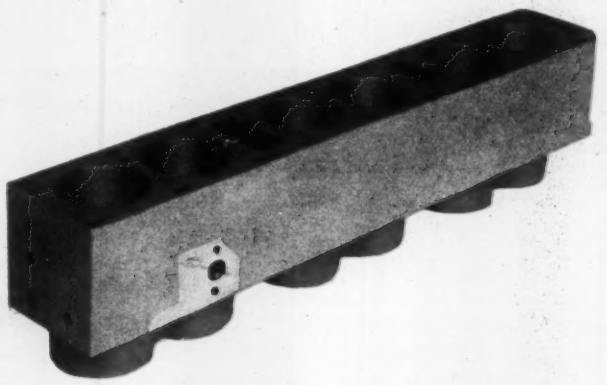


Fig. 4—Nickel cast iron cylinder block of uniform and simple design

of its design to give it uniform ability to withstand the stresses imposed on it. A rod designed from calculations alone may seem perfect but will break on account of unforeseen stresses at certain spots which the calculations fail to indicate. For example, our rod will hold up a 25,000-pound weight but if the weight is increased a few pounds the rod and bolts will begin to stretch. The rod will stretch fairly uniformly, except at the point at which experience shows us breakage due to the inertia forces generally occurs. When the engine becomes overheated the bolts cause stress in the rod at that point and fatigue fracture results.

Each of the three sprockets in the timing layout has 27 teeth and is of nickel steel, case hardened. There are no reverse bends in the chain. A chain wears according to the amount of bending which takes place as it passes over the sprockets, so the sprockets are made as large as the limit of peripheral speed will allow.

So many automotive engines have been built and so many experiments have been made that refinements in engine construction now develop slowly. Even a slight advance in engine design requires much hard work.

PROFESSIONAL VIEWPOINTS

Publication of letters does not necessarily imply that MACHINE DESIGN *supports the views expressed*

Comments from Our Readers. Machine Design Will Pay for Letters Suitable for Publication

More Ways Than One

To the Editor:

PRACTICAL experience with designers discloses two ways in which the two types of mind start their work. The student type of mind commences by making a full-scale layout of all the known factors, with additions of known or obvious details, before it begins to tackle the fundamental problem of the real design. The practical mind starts out by making simple quick freehand sketches of ideas, without dimensions, frills, or unimportant details; it goes after the big basic idea quickly. The student mind has not even begun to attack the real problem by the time the practical mind has evolved not only one but many possible solutions. Careful supervision can, in most instances, convert the inexperienced mind into the practical type.

Letting a designer follow and maintain contact with his work through the shops is an extremely important factor in his ultimate development. In this way, the alert type of mind often can discover improvements that otherwise would not suggest themselves.

—GEORGE H. GUNN,
Philadelphia

Calculating Moment of Inertia

EDITOR'S NOTE: *Below are given, first, a comment on John Flodin's article "Calculating the Moment of Inertia of Complex Sections," which appeared in the March issue, and following this a comprehensive reply to this comment received from the author of the article.*

To the Editor:

IN the article on computing the moment of inertia of the section by Prof. J. Flodin, showing a built-up steel section which is used as an example, I did not find any deduction made from the gross section for the rivet holes. Rivet holes in a common rolled steel I-beam often reduce the available, useful moment of inertia (or section modulus) over thirty percent, from the flange holes alone. As in built-up girders many holes necessarily may be punched in the flange angles and flange plates and also in the web, it appears to me that this should be clearly explained, and provision made for it in the printed tabular forms.

—F. W. SALMON,
Birmingham, Ala.

Calculating Moment of Inertia

To the Editor:

THE point raised by Mr. Salmon in connection with my article is well taken, for the necessarily somewhat brief mention of the effect of rivet holes hardly does the matter justice.

It is a mooted question whether rivet hole allowance should be made both for the tension and the compression sides of a beam, or for the tension side only. Some engineers contend that the rivet never fills the hole so completely that it

TABLE I

Calculation for Loss in Section Modulus for Beam Shown in Fig. 1

Item	Area A	Distance d	Area Moment dA	Second Power Moment d^2A	I_{cg}
Gross section	68.44				30012.5
Rivet (1)	— .47	2.625	1.24	3.3	
Rivet (2)	— .47	7.875	3.70	39.1	
Rivet (3)	— .47	13.125	6.17	80.9	
Rivet (4)	— .47	18.375	8.63	158.7	
Rivet (5)	—1.86	21.750	40.40	879.0	
Rivet (6)	—2.92	24.313	71.00	1726.0	.5
	6.66		131.14	2877.0	30012.0
	61.78				2887.0
					27135

Distance between geometric and neutral axes $= \frac{131.14}{61.78} = 2.12$ inches

$I = 27135 + (2.12)^2 \times 61.78 = 26857$ inches^4

$C = 24.25 + .75 + 2.12 = 27.12$ inches

$Z = \frac{26857}{27.12} = 990$ inches^3

reasonably can be assumed to transmit compressive stress, while others hold that with proper workmanship rivets transmit the full area quota of compressive stress, so that the compression side of a beam may be regarded as unaffected by the riveting.

Typical Example Is Given

Let us consider a common situation: a 24-inch, 80 pound I-beam with a 7/8-inch rivet in each flange, the area of the rivet holes to be deducted from both the tension and the compression sides of the beam. The grip of the rivets is 7/8-inch, so that the area to be deducted becomes 15/16-inch x 7/8-inch per rivet. The distance from the center of this area to the neutral axis is 11 9/16 inches. Hence the moment of inertia is reduced by $15/16 \times 7/8 \times 4 \times (11.56)^2 = 438$ inches^4.
The gross moment of inertia for this I-beam is listed as 2087.2 inches^4, so that the loss of strength is 21 per cent.

A more complex beam is shown in Fig. 1, for which the effect of the rivet holes in the tension or lower side is to be calculated. The beam was taken at random from the Carnegie Pocket Companion, the section modulus being given as 1200.5 inches^3, from which $I = 30{,}012.5$ inches^4. The gross area is 68.44 square inches. Since we know the gross moment of inertia the simplest calculation for the net moment is that given in Table I on the previous page.

In this table the rivet areas and the moments due to rivet areas are negative, so that the second power moments must be deducted from the gross moment of inertia, giving 27135 inches^4 as the net moment of inertia about the geometric axis. This quantity is reduced further because of the movement of the neutral axis by a distance of 2.12-inch, giving the corrected value, $I = 26{,}857$ inches^4, as shown. The net section modulus is 990 inches^3, showing a loss of strength of 17½ per cent.

If the gross moment of inertia had not been known in the above case, the approximate method suggested in the March issue could have been applied to good advantage. This method consists of allowing for the area lost in the rivet holes by substituting corresponding lighter sections, the effect being to spread out the areas of the rivet holes.

The substitutes of lighter sections of this type are indicated by "Eqv." in Fig. 2, the calculations being given in detail in Table II. It will be noted that the section modulus found by this method is 966 inches^3, or 2.4 per cent below the nearly correct value found in Table I. By substituting

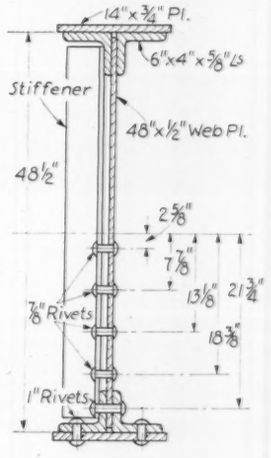


Fig. 1—Section of built-up beam showing areas lost on account of the rivet holes in the tension side of beam

5 x 3 x ⅝-inch angles instead of 6 x 4 x 7/16-inch, a section modulus of 1009.9 would have been obtained. The error here is only 2.01 per cent, but it is in the wrong direction so that the substitution made in the table is to be preferred. By using reasonable discretion in selecting the equivalent sections, the error can be made small in practically all cases, and it can be made to fall in the direction of safety.

In Fig. 2 the assumed axis was taken at the axis of symmetry of the beam. Normally it would have been taken perhaps two inches higher up, which would have decreased the width of the full-thickness web plate to 22 inches, and correspondingly increased the width of the reduced web. The axis of symmetry was used in this case for no better reason than to avoid giving

TABLE II

Calculation for the Net Moment of Inertia for Beam Shown in Fig. 2

Member	Area A	Distance d	Area Moment dA	Second Power Moment d^2A	I_{cg}
Upper fl. plate	10.50	24.625	259	6380	.5
Upper fl. angles	11.72	23.220	273	6330	15.0
Upper half web pl.	12.00	12.000	144	1728	576.0
			676		
Lower half web pl.	9.60	12.000	115	1382	461.0
Lower fl. angles	8.36	23.290	195	4530	11.2
Lower fl. plate	8.91	24.625	219	5410	.4
	61.09		529	25760	1064.1
			147	1064	
				26824	

Distance between geometric and neutral axes $= \frac{147}{61.09} = 2.41$ inches

$I = 26824 - (2.41)^2 \times 61.09 = 26469$ inches^4
$C = 27.41$ inches

$$Z = \frac{26469}{27.41} = 966 \text{ inches}^3$$

the impression that the previous calculation had been used as a guide.

Whether the reduced web thickness is taken as extending to the axis of symmetry or to some point above that axis, the assumed reference axis might quite as well have been taken at the bottom of the figure, as suggested by Mr. Bennett in the June issue of MACHINE DESIGN. Theoretically, any line in the plane of the section, normal to the plane of flexure, may be used as

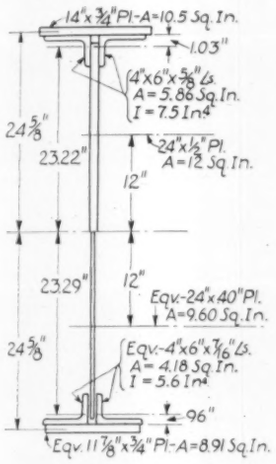


Fig. 2—Section of built-up beam showing substitution of lighter sections to compensate for areas lost by rivet holes in tension side

reference axis, the choice of location being largely a matter of convenience, if not of habit. In the case shown in Fig. 1 and in Table I, however, there is hardly any question but that the assumed axis should be taken at the geometric center of the beam.

—JOHN FLODIN,
Minneapolis.

Calculating Consumption of Air

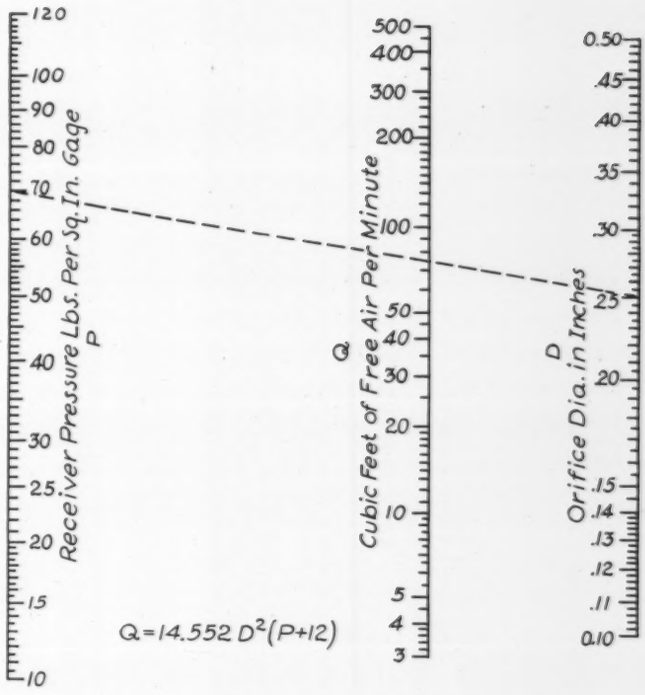
To the Editor:

THE graph presented by George T. Chapman, and printed on page 45 of the May issue of MACHINE DESIGN, can be represented by the following formula:

$$Q = \frac{160\,D^2}{11}(P + 12) = 14.55\,D^2(P + 12)$$

Where Q = cubic feet of free air per minute discharge
D = orifice diameter in inches
P = receiver pressure in pounds per square inch

This formula will give results for pressures above 10 pounds as accurately as the graph can be read. Pressures below 10 pounds are not often used in the work mentioned by Mr. Chapman. This formula should hold for orifice diameters between 0.1 and 0.5-inch.



One caution should be observed. Air flow through orifices depends largely upon the type of orifice used. The formula and graph apply only to the specific type used by Mr. Chapman.

From the formula presented it is possible to construct an alignment chart with which it becomes simple to determine the air delivery for any combination of air pressure and orifice size between the respective limits of say 10 to 125 pounds pressure and 0.1 and 0.5-inch orifice diameter. The problem illustrated by the broken line shows that with ¼-inch orifice under 70 pounds per square inch pressure, 75 cubic feet of air will be passed per minute.

—E. H. HAGEN,
Appleton, Wis.

Inventiveness or Ingenuity?

To the Editor:

IN YOUR editorial for May "Are Opportunities Broadening"? it is my belief that you have confused two terms: Inventiveness and Ingenuity.

Today we apply the term invention to almost any new arrangement of levers. Thirty years ago this was known as ingenuity. Perhaps it would be better for us to drop the old term entirely and use only the one term invention or inventiveness as the appliable term for all our changes in the world old application of mechanical principles.

The bow and arrow was but a primitive illustration of the leaf spring of today. What is the automobile spring but an inventive application of

(*Concluded on Page* 53)

MACHINE DESIGN

Systematize Development Work

Editorial

AN enterprising manufacturer is erecting an engineering and research building to house facilities for a personnel of 1000, whose work will be devoted entirely to developing new manufacturing processes. In another city a new building recently has been completed in which a large force of experts is engaged exclusively in working out new ideas for the company's products and reducing them to practical design.

THESE two instances—perhaps typical of others that could be cited—clearly indicate the trend of the times. They furnish evidence of the strenuous effort being made by manufacturers to keep abreast of general progress and to take advantage of every worthwhile improvement. The very fact that development work of this kind is being transformed from an informal, haphazard status to one of systematic, well directed effort is a most favorable sign. Nothing could prove more convincingly the growing recognition of research work.

THIS new attitude is bound to influence the thinking of those responsible for machine design. Companies whose executives have been willing to wait on new designs until an engineer has brought forth a new idea, in the future are likely to desire a more positive system whereby the incentive for design is consant and continuous. The best way to accomplish this end is to place development work on a systematic basis through the medium of a research department in which familiarity with market requirements, knowledge of engineering, genius for creating ideas and skill for crystallizing them into practical construction are brought together.

UNDER such a system, machine design will gradually become a profession of increasing importance and greater opportunity for the expression of real talent. Under the new plan, design engineers will be brought into more intimate contact with the sales, production, experimental, testing and other departments. The day of the old time designers, whose regular routine was more closely associated with ironing out minor mechanical faults than with the creation of original design ideas will pass when the thought of systematic development work permeates the mechanical industries.

IN this day of keen rivalry and accelerated progress in all arts and sciences, it is dangerous to trust one's business to the uncertain protection of hit or miss invention. The machinery builder who relies on the hope that his engineers, working without definite aim, may hit upon a successful design, is due for many disappointments. But if he organizes his personnel properly, gives it a definite plan of attack and utilizes the results of their work effectively, his machines always will reflect originality, good design and adaptability to the needs of his markets.

Is Standardization Sound?

MANY dissentments to the cause of standardization claim that it has a retarding effect on competition. In other words that development is hampered by the necessity of using a standard article in a design instead of a part specifically designed to meet certain requirements. That such is a narrow view in the majority of cases, however, is evident from a glance at the 1930 handbook of the American Standards Association. The list of names of eminent men and organizations sponsoring standardization movements indicates clearly that in the 12 years since the inception of the original American Engineering Standards Committee, standardization work is held in high esteem. Not only does it effect cost reductions in innumerable ways but it assists industrial organizations to tide over to some extent economically slack periods. With every standard promulgated, American business is placed on a firmer and sounder basis.

Rudolf Diesel and the Diesel Engine

Great Moments in Machine Design—Eleventh of a series of original drawings prepared exclusively for this magazine symbolizing the designer's contributions to the progress of mankind

NOTEWORTHY PATENTS

A Monthly Digest of Recently Patented Machines, Parts and Materials Pertaining to Design

ONE of the recent interesting inventions for a patent has been obtained is a spring clutch of the uni-directional type involving the principle of clutching together two rotable parts when one of them reaches a certain velocity or undergoes greater than predetermined angular acceleration. For the device William Carleton Starkey, Allisonville, Ind., has been granted patent No. 1,762,799. L. G. S. Devices Corp., Indianapolis, is the assignee.

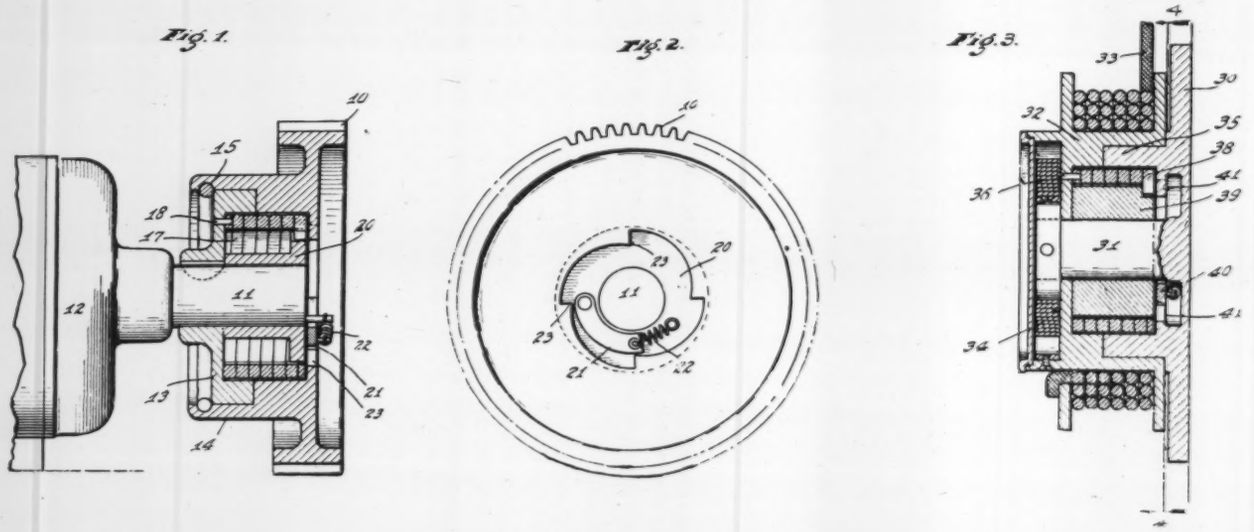
To accomplish the purpose of the invention one of the members is provided with an axial recess in which is located a coil spring connected to the other rotatable part. This spring is slightly smaller in diameter than the recess, and in cases where the clutch is controlled by rotational speed, centrifugal force comes into play, subjecting the spring to a torque and causing it to expand and grip the wall of the recess when the predetermined speed in reached.

When it is desirable to have the clutch controlled by acceleration the coil spring may be connected so as to rotate with that rotatable member, the acceleration of which will control the operation of the clutch. Connected through the coil spring is an inertia weight, so that when a given acceleration occurs the spring will be subjected to a torque sufficient to cause it to expand and grip the wall of the recess in the other rotatable member.

In the accompanying illustrations Fig. 1 is a longitudinal section through a clutch controlled by rotational velocity; Fig. 2 is an end elevation of the same unit and Fig. 3 is a longitudinal section through a trolley retriever embodying the clutch controlled both by acceleration and velocity. The application shown in Figs. 1 and 2 illustrates the clutch as operating between a driven member or gear 10 and a driving shaft 11 of an electric motor 12.

A helical coil spring 17 of normally a smaller diameter is located in the cup 13 and the bore of the gear hub 14. The spring is connected by pin 18 to the cup so that it rotates with both the cup and shaft 11. The other end of the spring 17 is fastened to a sleeve 20, which is rotatable. On the outer face of the sleeve 20 pawl 21 is pivotally mounted and connected to spring 22 which serves to hold the pawl inward and out of engagement with ratchet teeth 23.

Since the spring normally is smaller than the recess into which it fits, gear 10 and shaft 11 are



Figs. 1—2—*Clutch controlled by rotational velocity in which centrifugal force moves pawl* 21 *outward to engage one of the teeth* 23, *thereby imposing torque on coil spring* 17 *which unwinds and clutches cup* 13 *and gear hub* 14. *Fig.* 3 *is a trolley retriever*

free to rotate, but as the shaft 11 which carries with it the cup 13 and spring 17, reaches a certain rotational speed, centrifugal force causes the pawl to move outward. When it engages one of the teeth 23, a torque immediately is imposed upon the spring unwinding it and thereby increasing its diameter. It thus is caused to grip the inner walls of the cup 13 and gear hub 14 to clutch such parts together.

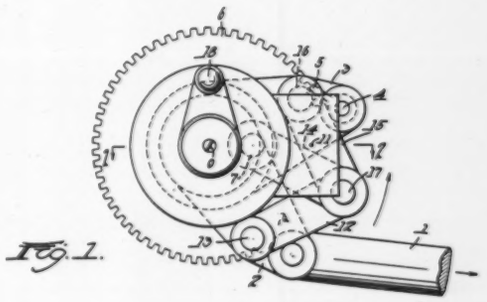
The trolley retriever shown in Fig. 3 incorporates a coil spring 34 operating between the shaft 31 and the spool 32, tending to rotate the spool in the direction to cause the cable to be wound up on it. Another coil spring 38 is located within the flange 35 and is operatively connected to the spool 32, by a pin 36. That end of the coil spring 38 which is not fastened to the spool 32 is connected to a rotating weight 39 mounted on shaft 31 shown in Fig. 3.

An inwardly spring-pressed pawl is mounted on the face of weight 39, and may be arranged to move outwardly and engage one of the teeth 41 on the plate 30 whenever the centrifugal force of the pawl is sufficient to overcome the spring pressure tending to move it outwardly. When the cable 33 is subjected to a strong outward pull causing the spool 32 to rapidly rotate, the inertia of weight 39 causes a torque on the spring 38. As the expanding spring engages the inner surface of flange 35, the spool 32 is locked to the plate 30 and further rotation and unwinding of the cable 33 is prevented.

VARIATION is possible in an adjustable mechanical movement which changes a constant reciprocating motion into an intermittent rotary motion, the object of patent 1,762,063 recently granted to George H. Knight, Torrington, Conn. It has been assigned to Hendey Machine Co., Torrington. In addition the device provides a convenient self-contained means for performing the adjustment. An indicator is provided which automatically shows the feed.

Referring to the accompanying illustrations, Fig. 1 shows an end view of the device and Fig. 2 is a plan of the same partly on a central radial section line 2-2 of Fig. 1. The connecting rod 1 is operated to have a constant motion and is pivotally connected to a lever 2 which swings freely on the axis of the stationary cast steel feed stud 9. Lever 2 is provided with a pivot stud 13 to which a link 12 is fastened. On the other end of link 12 is a pivot stud 17 on which are connected two links 14 and 15 as shown in Fig. 1. A stud 16 is mounted on a driven rocker arm 3 also pivoted on the stud feed 9.

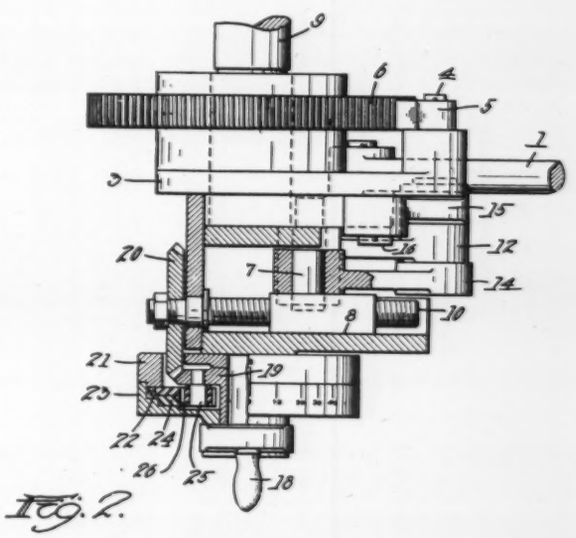
Rocker arm 3 oscillates about the feed stud 9 with the axis 0 as a center. It carries a stud 4 on which is mounted a pawl 5 that engages the teeth of the gear 6 which is loose on the stud feed 9. Oscillation of the rocker arm 3 determines the amount of feed per stroke of the connecting rod 1. This mechanism is designed to



End view of adjustable mechanical movement which changes reciprocating motion into intermittent rotary motion. Variation through an adjusting mechanism is a feature of the device

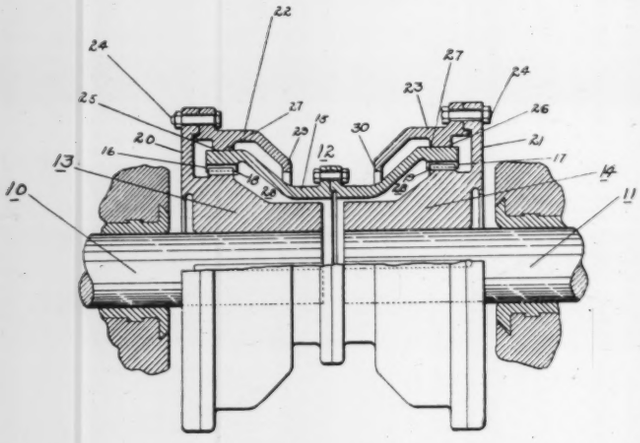
transmit constant motion of rod 1 to the rocker arm 3 and gear 6 in desired adjusted proportions. Feed stud 9 has a rectangular end provided with a T-slot 8 for receiving the head of the stud 7. A T-shaped head is provided with a screw thread and the frame of the feed stud 9 has a screw 10 which can be turned on its own axis but not reciprocated. By turning this screw the stud 7 will be adjusted along the slot 8.

An arm and handle 18 concentric with the feed stud 9 is mounted on the frame and as they are rotated a bevel gear 19 turns. This gear through bevel gear 20 turns the screw 10. A stationary disk 21 indicates the position to which the stud



Plan view of mechanical movement taken on section line 2-2 of Fig. 1. Arm and handle 18 are mounted on the frame and through bevel gears adjusts stud 7 along slot 8

7 is adjusted along the slot. Bevel gear 19 carries a stud 25 on which is a pinion 26, long enough so that it meshes with both of the gears 22 and 24. Turning the handle 18 causes differential motion to be set up between the stationary disk 21 and the rotatable disk 23. The scale may represent feed per stroke, feed per revolution or inches per minute. This invention was conceived for use on machine tools and therefore, the numbers appearing on the index dial on 23 may represent thou-



Sectional view of flexible shaft coupling in which annular members 22 *and* 23 *encircle the ends of sleeve* 15 *and are secured by bolts* 24 *to the outer edges of flanges* 18 *and* 19

sandths of an inch advance for each reciprocation of the operating rod 1.

IMPROVED construction and arrangement of parts of a flexible shaft coupling are covered by patent No. 1,759,338 recently granted to Robert C. Allen, who has assigned it to Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. The accompanying drawing is a part side elevation and a part longitudinal sectional view of the shaft coupling.

Driving connection is provided by rows of intermeshing teeth on the shaft hubs and the adjacent ends of the connecting sleeve, respectively. The teeth have a certain amount of clearance to facillitate any misalignment of the two shafts. Hub members 13 and 14 are keyed to the shafts 10 and 11 respectively. A two part sleeve 15 encircles the hub and is equipped at each end with internal teeth 16 and 17 which mesh with external teeth 18 and 19.

An annular bearing 25 is provided between the annular member 22 and the adjacent end of the sleeve. Likewise, there is an annular bearing 26 between 23 and the adjacent end of the sleeve. Bearings are furnished by integral rings 27 formed on the inner surface of the annular members. Hub members and sleeve provide space 28 which is filled with lubricant, which will be forced between the intermeshing teeth and to the annular bearings by centrifugal force.

CURRENT interest in oil burning engines emphasizes the significance of a recent patent covering an invention in this field by Clessie Lyle Cummins. The patent number is 1,762,653 and it has been assigned to Oil Engine Development Co., Columbus, Ind. In investigating oil burning engines the author of the invention has found that where the charge of fuel is injected by an injector into the combustion chamber of the cylinder, usually the fuel is not thoroughly distributed and complete combustion is not accomplished. Formation of carbon on the injector often causes it to become clogged and this along with other carbon deposits impair the efficiency of the engine.

To remedy these ills he has invented an engine which he claims provides improved means and a novel method for preventing the formation of carbon and effecting better distribution and more perfect combustion of the fuel. In the accompanying illustrations Fig. 1 is a vertical section taken through the upper part of a four-cycle engine, Fig. 2 is a bottom plan view of the inner cup-shaped member of the injector and Fig. 3 is a modified form of the carbon eliminating device.

Air is drawn into the cylinder past the air outlet valve 8 during the suction stroke of piston 7. At the same time fuel valve 16 is elevated and a charge of fuel flows through the oil conduit 27 into the space 23 and the conduits 22, thus forcing the charge of oil into the pointed end of the mixing chamber 19. As the liquid charge of oil is being deposited plunger 11 slowly is elevated. During the compression stroke of the piston part of the heated air compressed in the combustion space of the cylinder, is forced through the openings 24 and 18 into 19 where the oil is entrained

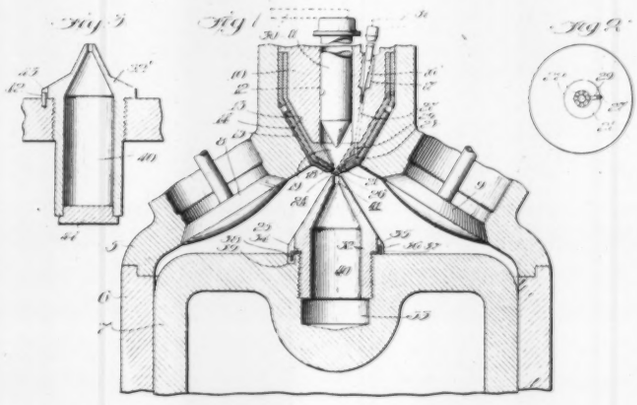


Fig. 1—*Vertical section through upper part of four-cycle oil-burning engine. Fig.* 2—*Bottom view of inner cup-shaped member of injector. Fig.* 3—*Modified form of carbon eliminating device*

and thoroughly mixed with air. Near the power stroke the fuel is ejected by the plunger 11 in the combustion chamber and ignited.

Member 32 together with the lower part of the bore 33 forms an air chamber 40 which is closed except for a nozzle 41. The piston 7 is shown at the extreme end of its upstroke. As the piston begins its downward movement on the upper stroke, the pressure in the combustion space 25 is decreased and the fresh air in the chamber 40 rushes out of the opening 41 feeding fresh oxygen to the zone of poor combustion or over-rich gases.

This rush of air through 41 also causes considerable turbulence around the injector and tends to scatter the charge with the result that better distribution and combustion is obtained. Air from 40 also sweeps the lower end of the injector clean of carbon deposits. During the compression stroke of the piston the pressure in the combustion chamber increases and a portion of the air rushes through the opening 41 into the chamber 40, being substantially balanced at the end of the compression stroke.

Review of Noteworthy Patents

Other patents pertaining to design are briefly described as follows:

BEARING—1,754,325. "In a bearing, relatively rotatable bearing members including one or more bearing segments weakened by their backs by a plurality of passages through which oil may circulate." Assigned to Kingsbury Machine Works Inc., Philadelphia.

LUBRICATING SYSTEM—1,758,250. "A lubricant dispensing coupling comprising a barrel, a supply member, a two-piece nipple of relatively small bore swiveled at one end to said barrel and at the other end to said member, and a sleeve carried by barrel and housing the nipple." Assigned to Alemite Corp., Chicago.

SUPERCHARGER—1,754,724. "A supercharger for internal combustion engines including a diffuser casing, a fuel inlet pipe, an impeller within the diffuser casing, a shaft for the impeller and speed multiplying gearing for the impeller shaft, the diffuser casing slanting from the fuel inlet pipe toward said gearing." Assigned to Pratt & Whitney Aircraft Co., Hartford, Conn.

OIL PUMP—1,765,724. In this invention a pump oiler comprises a casing having gear recesses and inlet and outlet openings in communication with the recesses. Intermeshing gears are positioned in the recesses, the gear having a distinct, independent interior oil duct for each face, said ducts extending from the peripheral portions of the gears to a side face thereof. Assigned to The Heil Co., Milwaukee.

PAPER FEEDING MECHANISM—1,766,106 "The combination, with a multigraph comprising a rotary drum and an impression platen, of a paper feed drum arranged to move at the same speed as the multigraph drum, means for automatically connecting and disconnecting a gear to the paper feed durm during a portion of one rotation of the multigraph drum." Assigned to American Multigraph Co., Cleveland.

PROFESSIONAL VIEWPOINTS

(*Concluded from Page* 47)

the bow, with the body taking the reverse action of the arrow?

Some one saw a wheel out of round and watched the bumpings and jarring that the primitive cart received. Then when he wanted to raise and lower a part in his crude machine, he recalled that wagon wheel and "invented" the cam. Was not the lever "invented" through some man blocking a rock, perhaps, with a long stick and then accidentally sitting down on the stick to rest, noting how easily he could raise the stone that had resisted his efforts before? Not a radically new thing, but a grouping together of two or more things of nature always at hand. A stick, a rock below, a rock above.

So it is today in all phases of design. We have only a certain number of fundamental mechanisms and the main idea behind the term inventiveness is to find the most ways to combine those mechanisms into the greatest variation of shapes or actuating mechanisms. None of them are new. The gear is but a combination of a cam and a lever. It was called a new invention at one time, but was it an invention or was it ingenuity in combining two primitive mechanisms. There will not be in the future any radically new discoveries in mechanisms, but there will be some radical developments in combining mechanisms and in associating the various rival powers, as electricity and hydraulics. It will be in these fields that the inventive genius of engineers will show itself.

The field is open to all contenders and the man who displays the greatest inventiveness or ingenuity in combining the primitive mechanisms and primitive forces will be acclaimed the greatest engineer of that age.

—C. G. WILLIAMS,
Green Bay, Wis.

Solid sections 18 inches in diameter have been joined in welds that are stronger than the original steel, T. McLean Jasper, director of research, A. O. Smith Corp., Milwaukee, told the Milwaukee section of the Society of Automotive Engineers at a recent meeting. Welds of a strength up to 200,000 pounds per square inch have been produced, and high characteristics can be obtained in ductility and resistance to fatigue and impact, he declared in his paper on "The Electric Welding of Steel."

MEN OF MACHINES

Personal Glimpses of Engineers, Designers, and Others Whose Activities Influence Design

NOMINATION of Vincent Bendix, head of the Bendix Aviation Corp., Chicago, as president of the Society of Automotive Engineers in 1931 was announced at the recent meeting of the organization. Election of the new officers takes place late this year, but inasmuch as there has never been a second ticket, nomination is tantamount to election. Ranking high as an inventor, engineer, organizer and business executive, Mr. Bendix has been a contributing factor to the development and success of the automotive industry almost since its inception. After his graduation from an engineering school in New York, he sold automotive accessories in Chicago, devoting his spare time to experimenting with his own inventions. Subsequently he evolved the Bendix starter-drive and perfected a four-wheel mechanical brake system.

AS a mechanical engineer for several railroads and editor for Simmonds-Boardman Publishing Co., Roy V. Wright, recently nominated president of the American Society of Mechanical Engineers, has rounded out 32 years of progressive service to the railway industry. He received his education in the public schools of St. Paul and the University of Minnesota where he was graduated with the degree of mechanical engineer in 1898. His railroad career included a position as chief draftsman and later mechanical engineer. In 1904 he became associate editor of the *American Engineer and Railway Journal,* and in 1910 assumed the position of mechanical department editor of the *Railway Age Gazette* which now is *Railway Age.* In 1911 he was appointed managing editor of that publication, which position he still holds in addition to his duties as editor of *Railway Mechanical Engineer.*

ILL health has made it necessary for Guiseppe Faccioli, widely known electrical engineer, to relinquish his duties as works engineer and associate manager of the Pittsfield works of the General Electric Co., and to assume the position of consulting engineer. Born in Milan, Italy, the son of an Italian army colonel, he came to this country more than 25 years ago. Employed first by the New York Edison Co. and later by the Interborough Transit Co., Mr. Faccioli then became a design engineer for the Crocker Wheeler Co. In 1908 he became identified with the General Electric company, Pittsfield works, where his mathematical genius proved unusually valuable. He spent considerable time at Schenectady with the late Dr. Charles P. Steinmetz, and as a member of the standardizing committee of the company, made important contributions.

ELECTION of Edmund A. Doyle as president of the American Welding society places at the head of that organization a man of wide knowledge and experience in the welding industry. He had been with the Linde Air Products Co., New York, since 1922 and now is one of its consulting engineers. Late in 1917 he entered the United States army as first lieutenant of engineering corps, achieving the rank of major. During that period he spent much time in designing and purchasing engineering equipment. Baltimore was the place of his birth in 1881. Prominent in American Welding society activities since its formation, he was a director of the organization for several years.

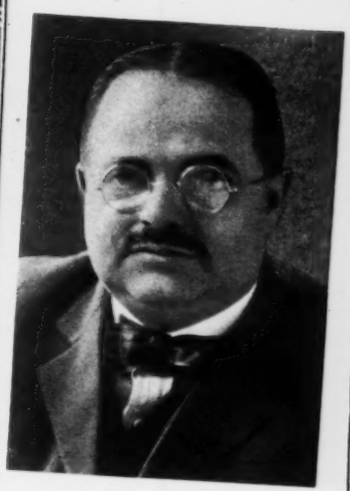
FOURTH award of the Charles B. Dudley medal, established by the American Society for Testing Materials in recognition of meritorious papers on research in engineering materials, has been made to J. R. Townsend, W. A. Straw and C. H. Davis, joint authors of the paper entitled, "Physical Properties and Methods of Test for Some Sheet Nonferrous Metals." Mr. Townsend, whose picture appears on the opposite page, is connected with the general development laboratory of Bell Telephone Laboratories Inc. Since his graduation from Baltimore City college and three years in the mathematics and dynamics branch of United States army ordnance, he has been largely connected with testing methods for metals.

THE appointment of J. A. Harlan as vice president in charge of sales of Frigidaire Corp., Dayton, O., is significant of the important role

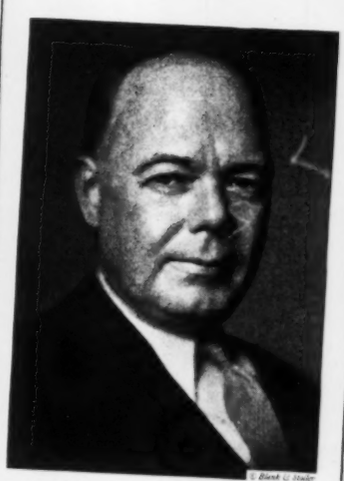
Leaders in Design, Engineering and Research

ROY V. WRIGHT

VINCENT BENDIX



GUISEPPE FACCIOLI



EDMUND A. DOYLE

J. R. TOWNSEND

J. A. HARLAN

engineers are playing in this phase of business and industry. Since 1915 when he was graduated in engineering from University of Michigan, Mr. Harlan has been with General Motors Inc. Leaving the engineering department of Buick Motor Car Co. the same year, he went to Dayton and entered the service of the Dayton Engineering Laboratories Co. He helped design the company's first farm lighting plant. While in the engineering department of the company after it became the Delco-Light Co., Mr. Harlan assisted in the design of an automatic farm lighting plant.

* * *

Earl E. Hodil has been made chief draftsman of Thomas Spacing Machine Co., Pittsburgh and Glenshaw, Pa., builder of fabricating machinery.

* * *

G. A. Johnson, chief mechanical engineer, W. H. Miner Inc., Chicago, was elected senior vice president at a recent meeting of the board of directors.

* * *

John E. Chiquoine has joined the sales staff of Blaw-Knox Co., Pittsburgh. He formerly was chief engineer of the American Chemical Machinery Co. and later with the industrial engineering division of E. I. DuPont de Nemours & Co.

* * *

John G. Wood, for two years director of engineering at Olds Motor Works, Lansing, Mich., has been appointed general manager of Muncie Products division, General Motors Corp., Muncie, Ind.

* * *

Milton C. Bauman has been placed in charge of engineering for Inland Aviation Co., Fairfax airport, Kansas City, Kan. He formerly was with the Dayton-Wright Co., and designed one of the United States entries in the 1920 Gorden Bennett cup races.

* * *

S. Johnson Jr. has been appointed chief engineer of the newly formed Bendix-Westinghouse Automotive Air Brake Co., Pittsburgh. He has had a wide experience in the automotive industry.

* * *

L. W. Chubb, former manager of the radio engineering department of the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., has returned to the company as director of the Westinghouse research laboratories. For some months he has been located in Camden, W. Va., as assistant to the vice president of the Radio Victor Co. He now fills the position vacated by the promotion of S. M. Kintner to assistant vice president.

* * *

C. G. Wennerstrom has been appointed chief engineer of Foote Bros. Gear & Machine Co., Chicago.

* * *

H. L. Miller has been appointed manager of the electric railway division, Pettibone Mulliken Co., Chicago. He formerly was chief engineer of the Buda Co., Harvey, Ill.

* * *

Eugene Hahn has joined the Treadwell Engineering Co., Easton, Pa., in connection with the manufacture of a line of bulk material handling and storage equipment developed by him.

* * *

W. E. Schaefer has been appointed chief engineer of Detroit Aeronautic Products Co., Detroit. He formerly was associated with the Stout Metal Airplane Co., and was connected with the building of the "Shenandoah."

* * *

E. A. Clark of the Philadelphia office of the Reliance Electric & Engineering Co., Cleveland, has been promoted to the engineering department in Cleveland where he will be engaged in the design of direct current motors.

* * *

Joseph Stout has resigned as engineer, passenger car division, of the Lycoming Mfg. Co., Williamsport, Pa. and has been replaced by Paul Gillian. John Oehrli has been appointed assistant chief engineer and P. B. Martin engineer, truck and industrial divisions.

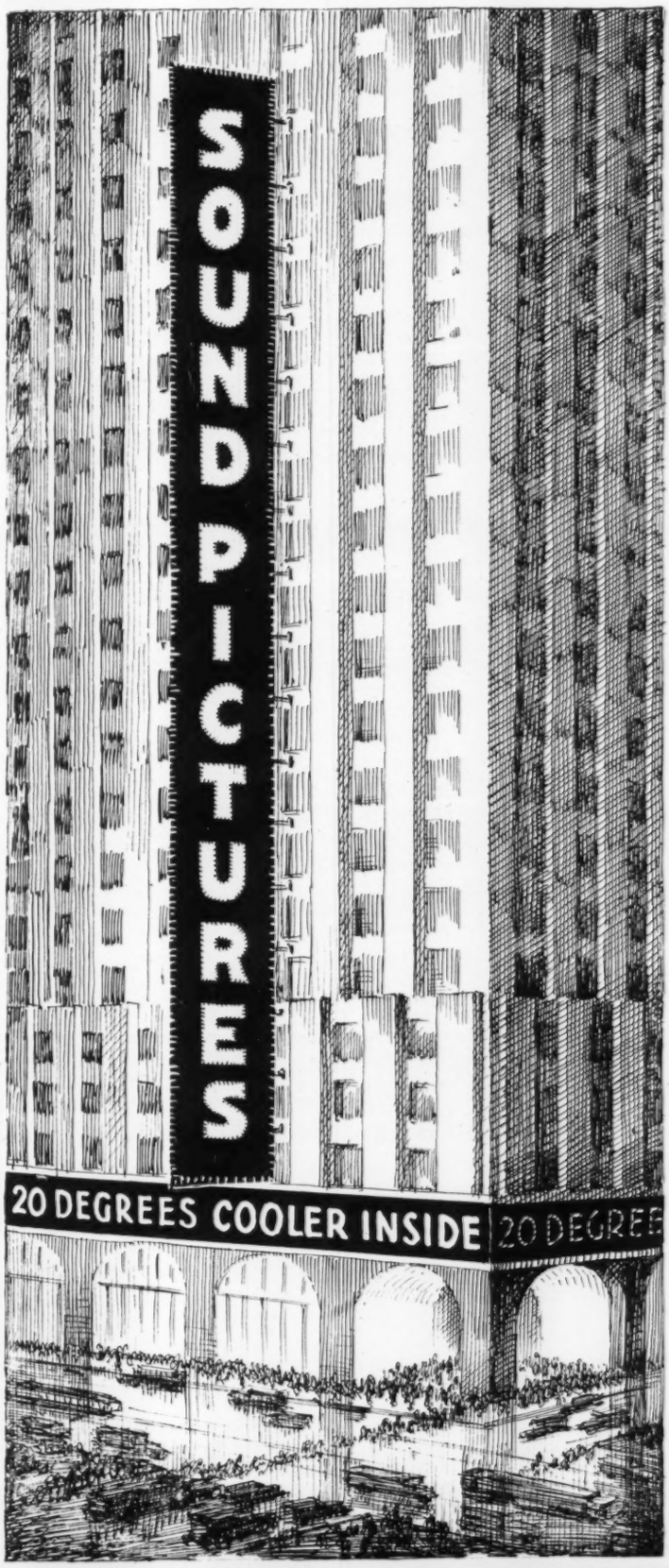
* * *

Gerard Vultree has been appointed to the position of project engineer for Detroit Aircraft Corp., with headquarters at Detroit. He formerly was chief engineer of Lockheed Aircraft Co. Richard Von Hake has been promoted to the position of chief engineer for the Lockheed company.

* * *

A. A. Ross, General Electric Co., Schenectady, N. Y., was unanimously elected chairman of the general standardization committee of the American Gear Manufacturers association at a recent

(*Concluded on Page* 74)



ON WITH THE SHOW

THOUGH the sidewalks sizzle with heat . . . though millions swarm to the beaches and resorts for relief . . . the modern moving picture theatre plays on to capacity crowds.

FOR when the mercury soars there is a difference of 20 degrees between the inside of the theatre and the walled canyons of heat represented by city streets. And it is this difference that has made possible the erection and profitable operation of the multi-million dollar moving picture palaces as well as the successful neighborhood houses of today.

UP-TO-DATE refrigerating and ventilating systems insure the comfort demanded everywhere by the money-spending public now. The operation of this equipment must be absolutely dependable for performances are continuous.

AND it follows as a matter of course, therefore, that many important parts of the motors, compressors and fans are made of cold finished steel bars and shafting. Here as in many different kinds of equipment where comfort, safety, economic manufacture and operation rests on the material used—*no other material takes the place of Columbia Cold Finished Steel Products.* Columbia Steel and Shafting Co., Mills and General Offices, Pittsburgh, Pa.

COLUMBIA
COLD FINISHED BARS AND SHAFTING

TOPICS OF THE MONTH

A Digest of Recent Happenings of Direct Interest to the Design Profession

JUNE was a month of conventions on which the eyes of the engineering profession were focussed. Each covered a variety of subjects peculiar to its own field with machine design enacting an important role. A discussion inspired by the annual meeting of the Society of Agricultural Engineers at Moline, Ill., June 16-19, claims that "machines used in agriculture are designed to stand greater strains than those encountered by automobiles and manufactured with as great precision as the most expensive cars."

William S. Lee, consulting engineer, and president of the W. S. Lee Engineering Corp., Charlotte, N. C., was elected president of the American Institute of Electrical Engineers at Toronto, Ont., June 23-27. Importance of design in machinery, particularly of the steel mill type, provided a major topic at the meeting of the Association of Iron and Steel Electrical Engineers at Buffalo, June 16-20. Committee A-10 reported up-to-date data on corrosion-resistant alloys at the meeting of the American Society for Testing Materials at Atlantic City, N. J., June 23-27. Other organizations meeting during the month were the Steel Founders' Society of America at White Sulphur Springs, Va., and The American Railway association at Atlantic City.

* * *

New Standards Year Book Is Published

Progress in standardization work affecting mechanical, electrical railways, mining and other American industries is reported in the American Standards year book for 1930. The standardization movement last year included the underwriting of $500,000 for national promotion work during the next three years, the affiliation of the association with national standardizing bodies of 20 other nations and an agreement between the association and the bureau of standards providing co-operation between government and private bodies in the promotion of industrial standardization.

American Railways association also has joined in the underwriting to the extent of $15,000 per year for a three-year period. The Standards association has approved 166 national industrial standards and has 171 under way. Of interest to engineers is the new standards for symbols for hydraulics, aeronautics, electric quantities, etc. A copy of the year-book may be obtained without cost by addressing the American Standards association, 29 West Thirty-ninth street, New York.

* * *

Pending Automotive Developments Cited

Reports emanating from the recent meeting of the Society of Automotive Engineers at French Lick Springs, Ind., place silencing and lubrication as the two major pending design developments in the industry. An engineer bent on obtaining the consensus of opinion learned this. Complete silencing of the engine, carburetor and fan and entirely automatic lubrication of all chassis bearings were uppermost in the minds of designers discussing this question.

* * *

Establishes Record Non-Stop Tractor Run

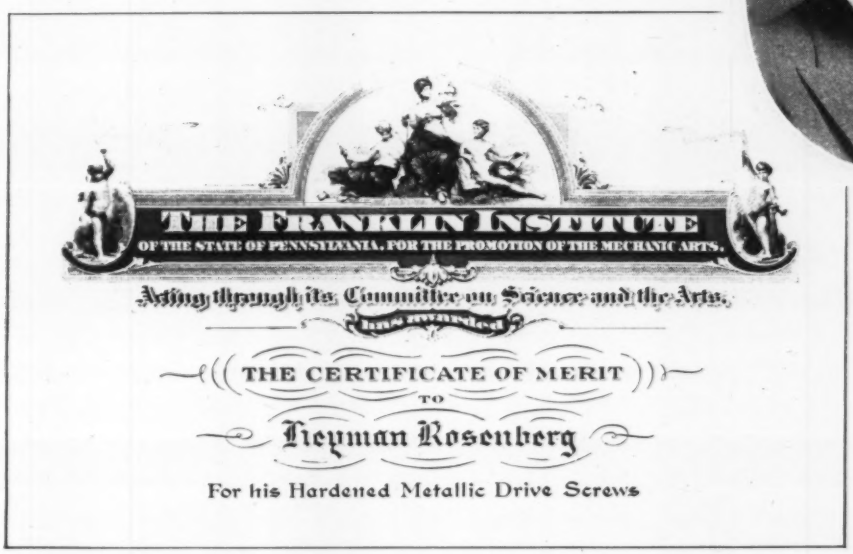
The longest continuous non-stop tractor run ended recently at the Oregon State Agricultural college after 480 hours without once stopping the engine. This test was made by the agricultural engineering department under actual farm conditions as a means of gathering exact data on wear, operation cost, reliability and other factors connected with the practice of modern power farming. When the word 'tractor" was coined a little more than 20 years ago about 600 machines were being manufactured annually. Last year a record output of 221,200 was reached in this country.

* * *

A. S. M. E. Holds Semiannual Meeting

Research to improve design of machine tools was advocated by E. F. DuBrul, general manager of the Machine Tool Builders' association, at one of the machine shop practice sessions held during the semiannual meeting of the American Society of Mechanical Engineers at Detroit, June 9-12. Establishment of a sizeable fund for this work was urged by Mr. DuBrul, who stressed the

In Recognition
of a notable contribution
to the Mechanic Arts . . .


THE FRANKLIN INSTITUTE
OF THE STATE OF PENNSYLVANIA, FOR THE PROMOTION OF THE MECHANIC ARTS,
Acting through its Committee on Science and the Arts,
THE CERTIFICATE OF MERIT
TO
Heyman Rosenberg
For his Hardened Metallic Drive Screws

The Franklin Institute

awarded

The Certificate of Merit

to the Inventor

of Self-tapping Screws

The award of The Franklin Institute's coveted Certificate of Merit to Mr. Heyman Rosenberg is only fitting recognition of his contribution to the mechanic arts. His Self-tapping Screws have greatly aided American industry, particularly in the development of mass production.

Enormous economies of assembly time and labor have been made possible by these unique Screws which are so hardened and threaded that they tap their own thread in metal as they are driven. Slow and expensive tapping, for 1500 years necessary to the assembly of metal products with screws, is no longer required for hundreds of assemblies.

TYPES OF SCREWS

1. *Hardened Metallic Drive Screws*... are simply hammered into drilled or formed holes. Used for making permanent fastenings to iron, brass and aluminum castings, steel, Bakelite, etc.

2. *Hardened Self-tapping Sheet Metal Screws—Type "A"*... are turned into drilled, pierced or punched holes with a screwdriver. They are used for joining sheet metal and making fastenings to sheet metal up to 14 gauge.

3. *Hardened Self-tapping Sheet Metal Screws—Type "Z"*... are turned into drilled, molded, punched or pierced holes with a screwdriver. Used for making fastenings to sheet metal up to 10 gauge; and to die castings, Bakelite, slate, ebony asbestos, etc.

4. *Hardened Screwnails*... driven like ordinary nails; hold like screws. Developed for fastening sheet metal securely to wood.

In the production of almost every kind of metal product...from cameras to airplanes . . . Self-tapping Screws have replaced machine screws and other devices. Notable assembly advantages have resulted . . . savings of thousands of dollars yearly have been effected. And better fastenings have been obtained.

Free trial samples of Self-tapping Screws will be gladly furnished . . . a description of your application brings them. As Vice-President of the Parker-Kalon Corporation, Mr. Heyman Rosenberg is available for assistance in solving difficult assembly problems.

PARKER-KALON CORPORATION
202 Varick Street New York, N. Y.

PARKER-KALON
HARDENED
Self-tapping Screws
PAT. IN U.S. AND FOREIGN COUNTRIES

need for development of machine tools beyond the ability of cutting tools. Cemented tungsten carbide has had a tremendous influence on design and to further the advancement of this work he sees as a possibility the use of laboratories of state universities, but was firm in the belief that companies should finance and supervise the work.

A technical session inciting a great deal of discussion was held under the auspices of the management division, with the American Management association co-operating. Three sessions on applied mechanics brought out much of interest, particularly to designers. Mechanical springs were discussed in two papers, one of which was presented by A. M. Wahl, research department, Westinghouse Electric & Mfg. Co., who has written a series of articles for MACHINE DESIGN.

* * *

Foundry Congress Features Exchange Papers

Exchange papers presented by representatives of foundry associations of America, Britain, France, Germany, Holland and Czechoslovakia were the high spots of the foundry congress held by the Association Technique de Fonderie de Belgique at Liege, Belgium, June 23-27. Technical sessions began June 24 with the discussion of cast iron testing methods and the presentation of papers. Among other subjects taken into consideration during the congress were high-duty cast irons and malleable cast iron.

* * *

Screw Thread Standard Adopted by Producers

A commercial standard for special screw threads, section II, of the American national screw thread tables for shop use has been adopted by a majority of manufacturers and users as recommended by the bureau of standards, Washington, and became effective as standard for new production on July 1. Signed acceptances from a large number of persons interested were returned to the bureau in reply to an inquiry sent out last January. Many producers and users have followed the reports of the national screw thread commission for several years and for such organizations the effective date will indicate no change in practice. The chief purpose of the effective date is to identify the acceptors of record with the commercial standard.

* * *

Sees Possibility of 100-Ton Metal Airship

A metal-clad airship weighing 100 tons would be practical to build and operate, C. F. Kettering, president of the General Motors Corp., recently told the house military affairs committee. He said that the metal hulls can be made gas-tight by sewing the plates together with three rows of rivets simultaneously at the rate of 5000 rivets an hour. In fact as an engineering feat, Mr. Kettering said, it would be easier to build a large metal-clad airship than the present small ZMC-2, which is one-eighth the size originally planned.

* * *

Patent Applications Increase as Rate Rises

Applications for patents totaling more than 3500 arrived at the government patent office at Washington in the last week of May before the rate was advanced to $25 from the former level of $20. This was almost double the number of average weekly receipts of first applications, according to Commissioner Thomas S. Robertson. Compared with other industrial nations, the United States in 1928 led the world in the number of patents issued, being nearly 200 per cent ahead of its nearest competitor, France. With four weeks required by the government printing office to issue a patent, the *Official Gazette* of June 24 contained nearly 3200 instead of the usual 800 patents.

* * *

Alloy Castings Division Organized Recently

The Alloy Castings division of the Steel Founders' Society of America was organized recently in Cleveland during the convention and exposition of the American Foundrymen's association. The division is composed solely of producers of alloy castings and heat and corrosion resisting products. Its purpose is to promote general improvement in the manufacture and sale of alloy castings to correct abuses, to collect and diseminate information on labor conditions, to procure uniformity of customs and usages in the trade and to maintain a high standard of product.

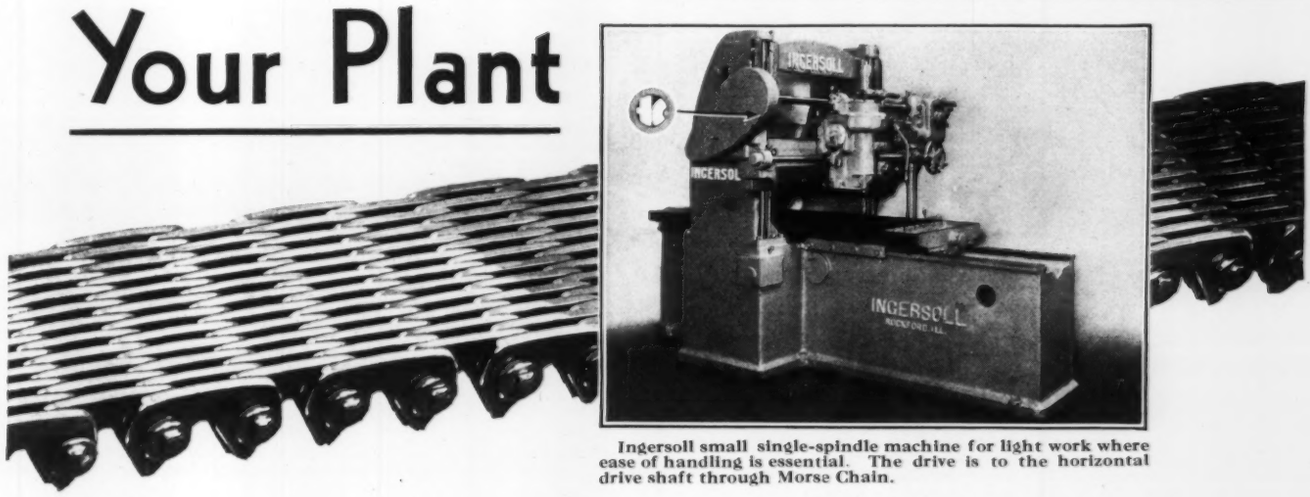
* * *

Hydraulic Laboratory Bill Becomes a Law

Appropriation of $350,000 for construction and equipment of a hydraulic laboratory in Washington is authorized by the national hydraulic laboratory bill which recently became a law with the signature of President Hoover. One of the functions of the new measure will be the development and testing of hydraulic instruments and accessories.

The bill first was introduced by Senator Ransdell, of Louisiana, Sept. 8, 1922, at the suggestion of John R. Freeman, who has specialized in hydraulics for more than 50 years. It met with some opposition but in January of this year, Senator Ransdell again presented his measure and Representative O'Connor reintroduced it in the House.

If You Build or . .
Rebuild, Rearrange . .
Add Capacity
or Modernize
Your Plant



Ingersoll small single-spindle machine for light work where ease of handling is essential. The drive is to the horizontal drive shaft through Morse Chain.

Phone
MORSE
of course

No matter how complicated your power transmission problems, trained Morse Power Transmission engineers can show you how to insure against production interruptions, conserve floor space, save power—show you the short cuts to efficient operation. They know how to design and install the drive best suited to your needs.

In many instances this service, with the installation of Morse Silent Chain Drives, Flexible Couplings or Speed Reducers, has speeded up operations, cut production costs and created savings far in excess of original expectations. We have reports on installations that have operated efficiently for 15 and 20 years, and on others that have saved thousands of dollars.

Morse Power Transmission Service is available in the principal centers of the country. A 'phone call, wire or letter will bring the Morse Engineer to your plant to consult with you entirely without obligation.

Write for free data file pertaining to your business.

MORSE CHAIN COMPANY
Ithaca, New York

MORSE SILENT CHAIN DRIVES

NEW MATERIALS AND PARTS

Worthy of Note by Those Engaged in the Design of Mechanisms or Machines

New Material Developed for Chains

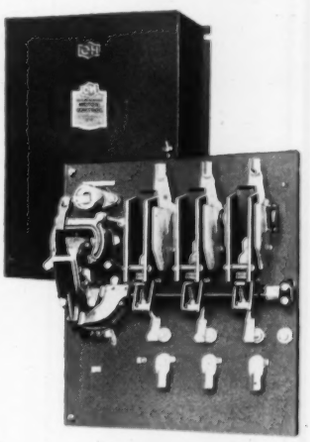
A NEW line of cast chains showing remarkable strength and durability has been placed on the market by Link-Belt Co., Indianapolis. These chains are sold under the registered trade name of Promal and are the result of extended research to provide longer life for drive and conveyor chains operating under heavy loads or abrasive conditions. Experiments with cast chain metals, started about four years ago, led to the discovery of a new method of processing malleable iron which so altered its physical characteristics as to make it a distinctly new metal.

Compared with malleable iron, Promal has an average yield point of 45,000 pounds as against 36,000 pounds; an average ultimate strength of 65,000 pounds as against 54,000 pounds; an average elongation of 14 per cent as against 18 per cent; and a brinell hardness of 170-190 as against 110-130. Compared with mild cast steel, annealed, this metal has an average yield point of 45,000 pounds as against 34,000 pounds; an average ultimate strength of 65,000 pounds as against 60,000 pounds; an average elongation of 14 per cent as against 26 per cent; and a brinell hardness of 170-190 as against 120-140. High temperature reduces its tensile properties somewhat, but temperatures up to 1000 degrees Fahr. will not cause it to become brittle.

Promal chains are particularly recommended for four general classes of service: (1) chain drives, elevators and conveyors operating under gritty or abrasive conditions; (2) chain drives where great strength is required; (3) drag, scraper and flight conveyors where the chain drags and is subject to abrasion; and (4) heavy duty drives of comparatively high speed, short centers and large sprocket ratios.

Left—Chain link of newly developed material for wide range of service under heavy loads and abrasive conditions. Yield point is 45,000 *pounds and brinell* 170-190

Right—Magnetic contactor designed for heavy duty alternating current service and arranged for two or three wire control. The 300 *ampere size is shown in the illustration*



Contactors Designed for Heavy Duty

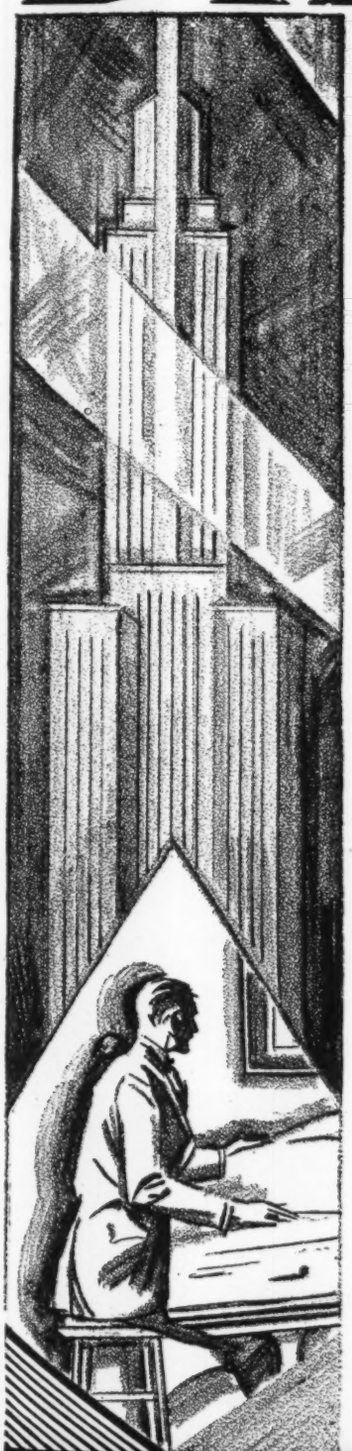
TWO new magnetic contactors, for heavy duty alternating current service, recently were announced by Cutler-Hammer Inc., Milwaukee. The units are rated for maximum capacities of 300 and 600 amperes respectively, the accompanying illustration showing the 300 ampere size.

Features of these new contactors make them generally applicable to all heavy-duty requirements. They are arranged for either two or three wire control, have continuous duty operating coils, highly efficient magnet structure and exceptionally heavy, butt-type, solid copper contacts. An air cushion absorbs the shock of the magnet on closing, thus reducing wear and making the con-

Standardize on

DIETZGEN

DRAFTING & SURVEYING SUPPLIES



DIETZGEN today has a most complete and standard line of drafting and surveying instruments, supplies and furniture—superlative quality blue print paper to meet every requirement of architectural, professional, industrial or school drafting. The name DIETZGEN is a reliable guarantee of quality and satisfaction.

Our widespread distributing and service organization bears evidence of the success of the policy of ever being on the alert, constantly experimenting in research and design, and ever seeking new and better methods of producing finer products.

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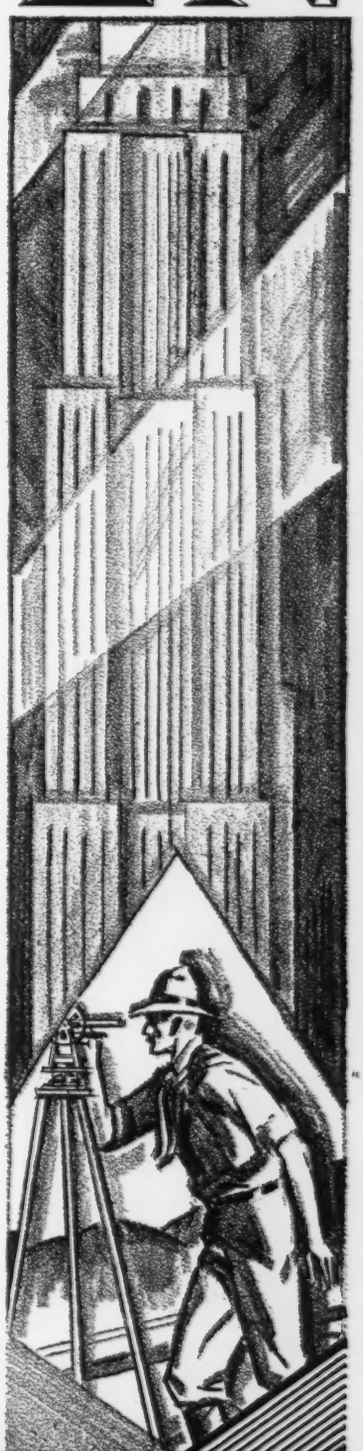

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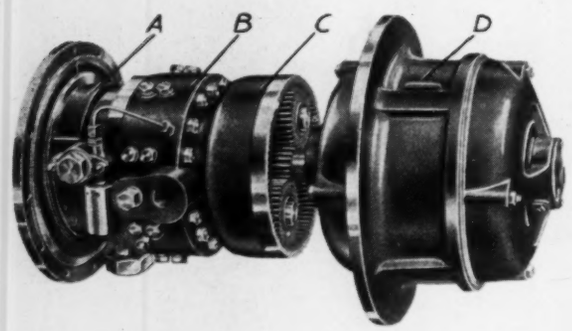
tactor operate more quietly. For general use, the 300 ampere contactor is mounted in a wall-type enclosure, and the 600 ampere size is in a floor-type case.

Develops Hydraulic Pressure Pump

QUICK control by a handwheel giving any desired pressure from 300 to 4200 pounds per square inch is one of the features of the hydraulic high pressure pump type BM recently announced by Index Machinery Corp., Cincinnati. Automatic change from low to high pressure, automatic oiling through the pressure oil and variable delivery of oil in the high pressure stage are other outstanding points.

These new hydraulic pumps are so constructed as to eliminate accumulator systems with long pipe lines. They can be used in connection with all kinds of hydraulic presses, such as push broaching, bending and straightening, assembling and testing presses and have unusual advantages for use on machines to mold plastic materials. Low and high pressure stages, as shown in the



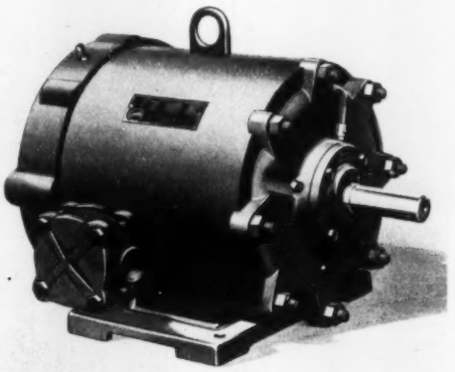
Hydraulic pressure pump unit showing direct connected motor D, planetary gears C, low pressure stage A and high pressure stage B

accompanying illustration, are assembled in one housing and driven by the same shaft. The housing is cast iron with integral cast steel pipes and moving parts are chrome nickel steel.

Announces Explosion Proof Motor

DESIGNED to meet motor requirements in explosive atmospheres, a type E unit has been announced by Louis Allis Co., Milwaukee. The motor proper is built in a totally enclosed metal casing, which consists of a welded steel stator unit and two cast iron bearing brackets held together by eight tie bolts. The mechanical design of this enclosed casing incorporates two explosion proof features of the motor enclosed by sheet steel.

Ability to retain the flame, and strength to withstand the pressure in case of an internal explosion characterizes the newly developed unit, an



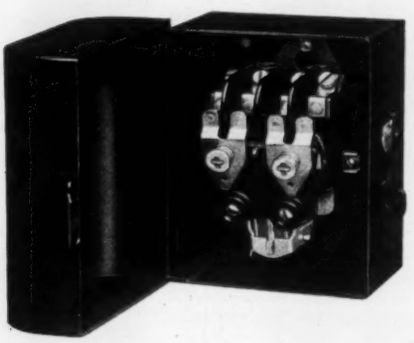
View showing end of motor where cooling air is discharged. Outer shell directs air over surface of inner casing

end view of which is shown in the accompanying illustration.

A blast of cooling air is forced through a ½-inch passage over the motor by an aluminum fan mounted on an auxiliary shaft extension.

Contactor Has 15 Ampere Capacity

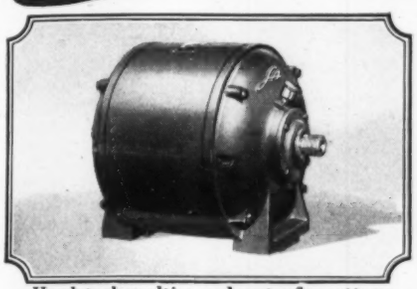
A SMALL motor contactor known as class 8511 has been announced by Square D Co., industrial controller division, Milwaukee. The



Interior of small motor contactor for application where single phase motor is controlled by push button, thermostat or vacuum switch

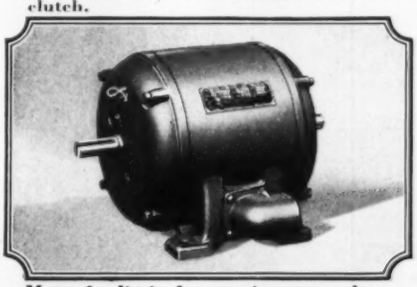
field for this contactor includes oil burners, small refrigerating systems, small unit heaters and any application where a single-phase motor is to be controlled by push button, thermostat, pressure or vacuum switches. The capacity is 15 amperes

"CUSTOM-BUILT" MOTORS *increase machine efficiency*



Headstock multi-speed motor for pattern lathe. Tongue in feet for mounting direct on ways of lathe. 4-speed winding eliminates speed changing gears and clutch.

Vertical motor with drip-proof covers. Used on over-driven extractors equipped with automatic centrifugal built-in clutch.



Motor for limited mounting space—has shortest possible over-all length. Used for precision grinders and with brakes for hoists.

HERE is another interesting group of Louis Allis "custom-built" motors. They reflect the modern trend in machine design. They illustrate some of the special refinements that result when motors are considered in the *original design* of production machines—instead of as "afterthoughts."

L.A. "custom-built" motors are developed through close co-operation of L.A. engineers with our customers' engineers. In fact, our greatest success has resulted when these co-operating engineers exchange visits—at our customers' plants, our plant, and "on the job"—together to study and solve the motor problem.

Thus L.A. "custom-built" motors are provided with whatever special refinements are needed to *help* the completed machine perform as a modern production unit. That is how L.A. "custom-built" motors become integral parts of the machines they drive—eliminate unnecessary parts, needless friction, and lost motion—and actually *increase machine efficiency.*

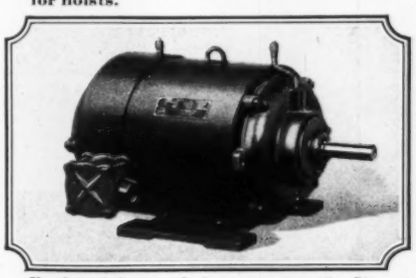
Why not profit by our long experience? Perhaps your machines, too, can be made more efficient—and therefore more saleable. L.A. engineers are ready to co-operate with you in designing or selecting motors exactly suited to your needs.

To increase Machine Efficiency—
Specify L.A. "Custom-Built" Motors

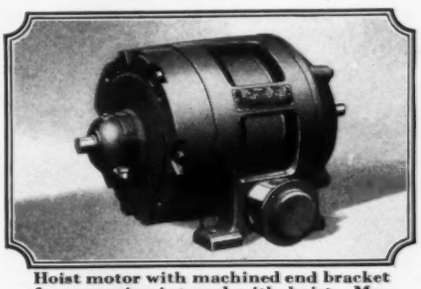
Prompt Deliveries **Nationwide Service**

Write for bulletins describing following types of L.A. "custom-built" motors:

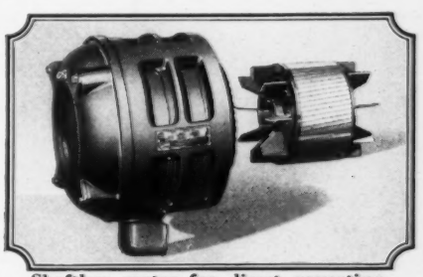
No. 500 —Multi-speed squirrel cage motors.
No. 502A—Inverted rotary converters.
No. 504 —Slip-ring motors.
No. 505A—Squirrel cage motors.
No. 507—Direct current motors.
No. 508—"Explosion-Proof," fan-cooled motors.
No. 509—Frequency converters.
No. 510—Totally enclosed, fan-cooled motors.



Enclosed fan-cooled motor, type J. Size practically same as open motor. Used on buffers, polishers, grinders, drills, or wherever motor is subjected to excessive metallic dust, drillings, moisture, acid, etc.



Hoist motor with machined end bracket for mounting integral with hoist. Machined pad and auxiliary shaft extension on front end for mounting brake. Special high torque winding.



Shaftless motor for direct mounting. Eliminates mounting bracket and coupling. Used on machine tools and woodworking machines.

LOUIS ALLIS

"CUSTOM-BUILT" *Electric* MOTORS

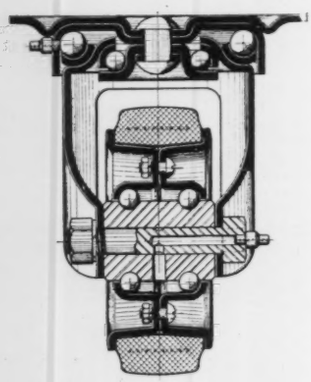
THE LOUIS ALLIS COMPANY
MILWAUKEE, WIS.

Motor Specialists for 29 Years — *Offices in Principal Cities*

and is for use with motors up to 1½ horsepower, 110 volts and 3 horsepower, 220 volts. The contactor is 5 inches wide, 6¾ inches high and 4¾ inches deep. Net weight is 3¾ pounds.

Casters Designed for Heavy Duty

THE Saginaw Stamping & Tool Co., Saginaw, Mich., is manufacturing a line of casters, one type of which is shown in the illustration below.

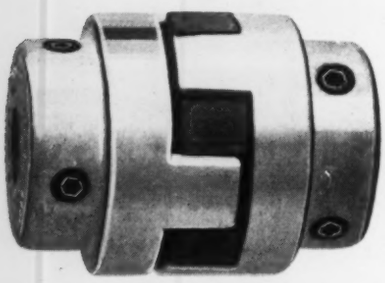


Sectional view of caster equipped with hardened ball bearings and constructed of heavy gage steel

This caster is a heavy duty unit designed to meet rigid requirements. Mounted throughout on hardened ball bearings and built entirely of heavy gage steel, it has hardened ball races in the swivel and wheel bearings. On this particular type the tire is molded rubber with a metal insert to prevent stretching. The tire is demountable and can be renewed when worn out. Metal surfaces are rustproofed by the Parkerizing process. Another model, the "Master" caster is furnished either in rigid or differential types, pressed steel wheels, and can be equipped with Alemite fittings.

Coupling Features Flexible Spider

SUBSTITUTION of a flexible spider for a set of independently acting resilient rollers in the L-R flexible coupling to provide added advantages,



Flexible coupling with removable flexible spider. Three parts comprise the unit which is reversible

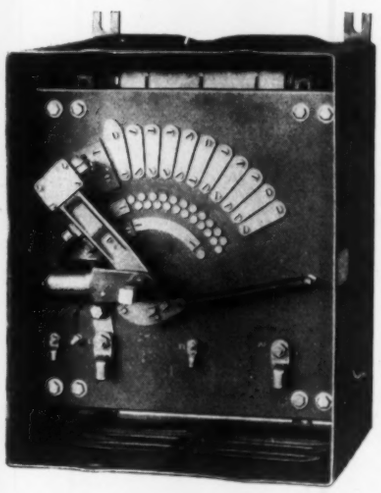
has been announced by Lovejoy Tool Works, 32 West Ohio street, Chicago. Essentially a jaw coupling with loosely floating resilient members, the coupling combines strength, silence and accessibility. In replacing the individual resilient members with a flexible spider, the unit introduces a new principle in coupling design.

Because of its unusual simplicity of design, this coupling may be easily adjusted and aligned in a minimum of time with the aid of a set screw wrench only. Removal of the spider takes but a few seconds and may be accomplished without disturbing the alignment of the shafts or removing the coupling itself from the shafts. It only is necessary to loosen the set screw and slip one member of the coupling far enough back on the shaft to release the spider.

As shown by the accompanying illustration, there are only three parts to the coupling. It is reversible, and opposing members are interchangeable providing both are bored for the same shaft-size.

Develops Three New Type Rheostats

THREE new direct-current speed regulating rheostats designated as Classes 7350, 7310, and 7210 have been placed on the market by



Direct current speed regulating rheostat equipped with a spring contact arm which returns to "off" position in case of voltage failure

Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. These rheostats are used for starting and regulating the speed of shunt or compound-wound, direct-current motors in non-reversing service, class 7350 being used where a 50 per cent speed reduction through armature control and 25 per cent increase by field control is desirable, class 7310 where a 50 per cent speed reduction through armature control only is desirable, and class 7210 where an increase up to four times full speed through field control is desirable.

With all these types of rheostats, the motor is started by moving the rheostat handle to the right. The contact arm is provided with a spring

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ALEMITE ADDS PLUS VALUE TO *YOUR PRODUCT*

TO manufacture machinery mechanically capable of doing the work for which it is intended, is not enough. For the treatment it receives when actually installed, is often the deciding factor in its record of performance. And this—in the past, at least—has been a factor beyond your control.

Knowing that 80% of all breakdowns are caused by insufficient or faulty lubrication, what assurance have you that your product will receive proper care once it leaves your hands? What insurance have you provided for complete customer satisfaction?

Alemite Lubrication now offers sure protection to your reputation as a builder of trouble-proof machinery. Designing this simple, inexpensive lubricating system into your equipment eliminates the major cause of machinery failures—improper lubrication.

Moreover you have added a plus value to your product. In thousands of industrial plants Alemite is making a record for savings in labor, lubricant and repair work costs. That is the reason that today 1100 leading manufacturers of machinery are specifying Alemite Lubricating Systems as standard equipment.

Make a test case of Alemite efficiency in your own shops. We will supply you with free cost sheets, which enable you to make an accurate comparison of this modern lubricating system with obsolete oil-hole and grease cup methods.

Alemite Corporation (Division of Stewart-Warner), 2644 North Crawford Avenue, Chicago, Illinois.

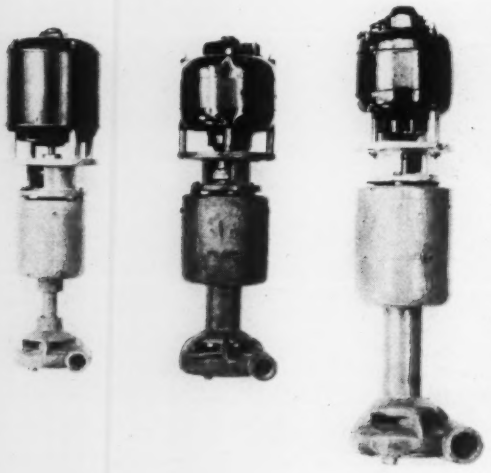
ALEMITE PRODUCTS

which returns to the "off" position in case of voltage failure.

Classes 7350 and 7310 are provided with a low voltage mechanism which holds the rheostat arm on any contact and prevents leaving the arm between contacts where proper contact would not be obtained. Class 7210 rheostat has two arms, one of which cuts out the other which cuts in the field resistors. When the arm reaches the position where all of the starting resistors are cut-out, the armature contact is held in place by a magnet. The field contact arm is so interlocked with the armature contact arm that the field resistance can be cut-in for speed regulation only when the armature contact is in the "run" position. It must always be returned with the armature arm to the "off" position.

Pump Is Made in Three Sizes

CAPACITIES ranging 10, 20 and 50 gallons per minute are available in the new Gyro coolant pump recently announced by The Equipment Co., Detroit. In this unit there are no packings to leak and no screens to clog. Coolant cannot contact with the bearings and it is always primed. Water is handled with equal efficiency, it is claimed. To meet conditions a variety of drives including vertical and right angle types as well as flexible shaft drives are obtainable. Three sizes equipped with



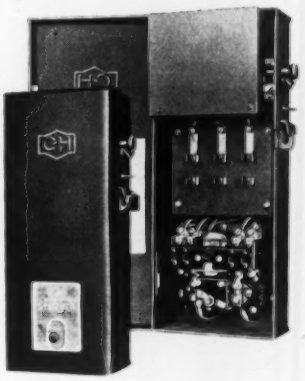
Three sizes of coolant pump with capacities ranging 10, 20 *and* 50 *gallons, showing motors mounted vertically*

motors mounted vertically are shown in the accompanying illustration.

The drive shaft is integral with the counterweight and the sealed ball bearing is permanently lubricated by being packed with grease. Balancing of the counterweight eliminates vibration and chatter marks, maintains concentric operation and distributes wear on the ball bearings. Arches above the impeller are designed to eliminate swirl in the tank. The intake is by gravity feed and the outlets have standard pipe threads.

Develops Across-the-Line Starter

DEVELOPMENT of a new alternating current across-the-line, automatic starter combined with a fusible disconnect switch in a single steel



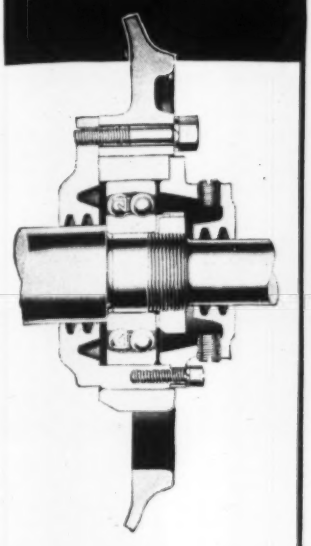
Across-the-line automatic starter with cover interlock which prevents opening when the switch is closed

enclosing case has been announced by Cutler-Hammer Inc., Milwaukee. This new starter may be used in place of the separate starter and fusible disconnect switch. A feature is a wiring channel between the starter panel and the back of the enclosing case which allows running the connecting wires behind the panel, where they cannot interfere with the operation of the starter. Ample room is provided to bring all of the connecting wires in at either the top or bottom.

All parts are mounted on a back plate which is easily removed for pulling and placing of line and motor wiring. The disconnect switch is manually operated from the outside of the enclosing case. A cover interlock prevents opening the cover when the switch is closed and prevents closing the switch if the cover is open, unless the interlock is manually released. An electrical interlock insures that the magnetic contactor of the starter is always open when the disconnect switch is open. The fuse clips are mounted on a slate base, just below the disconnect switch.

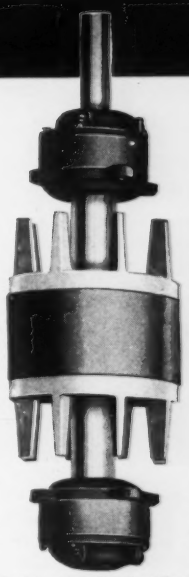
Conveyor Device Insures Safety

SAFETY in operation of conveyors is insured by a control device recently developed by Kurth & Knapp Mfg. Co., Detroit. The safety



Self-aligning, double-row ball bearings mounted in sealed shell which excludes dust and dirt

Type Q, Normal Torque, Normal Starting Current Standard Squirrel Cage
Type QLS, Normal Torque, Low Starting Current for Full Voltage Starting



Complete rotor showing the sturdy shaft and large, completely sealed ball bearings

Built to do a *better* job

BY combining long-time dependability with operating economy, F-M Type Q and QLS Induction Motors are helping to minimize operating costs. These motors are built by Fairbanks-Morse—an organization with an experience of more than a quarter century of successful motor building. They are built with but one purpose in mind—to do a *better* job for a *longer* time.

It is natural to expect improvements in design—refinements in construction—in motors that deliver the kind of service that these do. A glance at the features listed on this page will partly explain Type Q and QLS superiority. Let us send the whole story—or let an F-M engineer explain how these motors will help you cut power costs.

1930
begins the
SECOND CENTURY
of building
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FAIRBANKS-MORSE MOTORS

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POWER, PUMPING AND WEIGHING EQUIPMENT

Read about F-M Sealed Ball Bearings and other construction features

Sealed ball bearings mounted in cartridge type housings. Bearings are kept clean always. Grease but once a year.

Pressure cast aluminum rotor construction with rotor bars, end rings and fan blades cast integral on smaller sizes.

Copper rotor bars electrically welded to the end rings, and fan blades cast integral with the end rings on larger sizes.

Substantial, rigid stator heads with feet cast integral.

Electrically welded zones across outer surface of stator laminations at several points, giving rigidity to stator core.

Effective ventilation secured by directing air through the motor—eliminates hot spots.

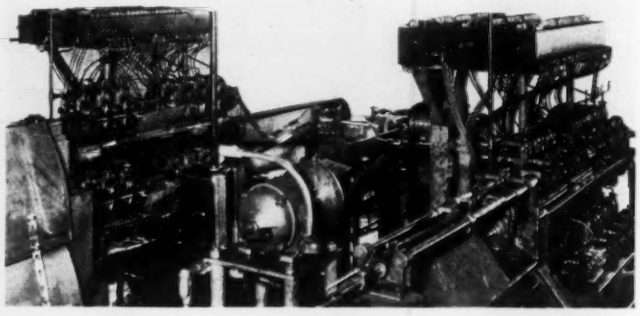
Laminations fully exposed to the outside air. Provides maximum radiating surface.

Stator end shields made heavy so as to rigidly support shaft, protect stator coils and direct the cooling air.

Permanently plastic insulation which retains its original strength and insulating qualities unimpaired for years.

Starting effort that provides quick start and rapid, smooth accleration up to full speed under severe conditions.

stop may be equipped with a limit switch, automatically shutting off power to the conveyor drive, this bringing the entire system to a standstill when the conveyor chain breaks. It consists of a one-piece forged steel crank composed of a guard arm and a lock arm inserted in a bearing block which is bolted rigidly on the top of the monorail conveyor. The guard arm oscillates over trolley wheels as they pass at normal speed. When struck with a runaway trolley this guard arm is thrown violently upward against a stop block forcing down the lock arm which catches and automatically stops the trolley wheel.



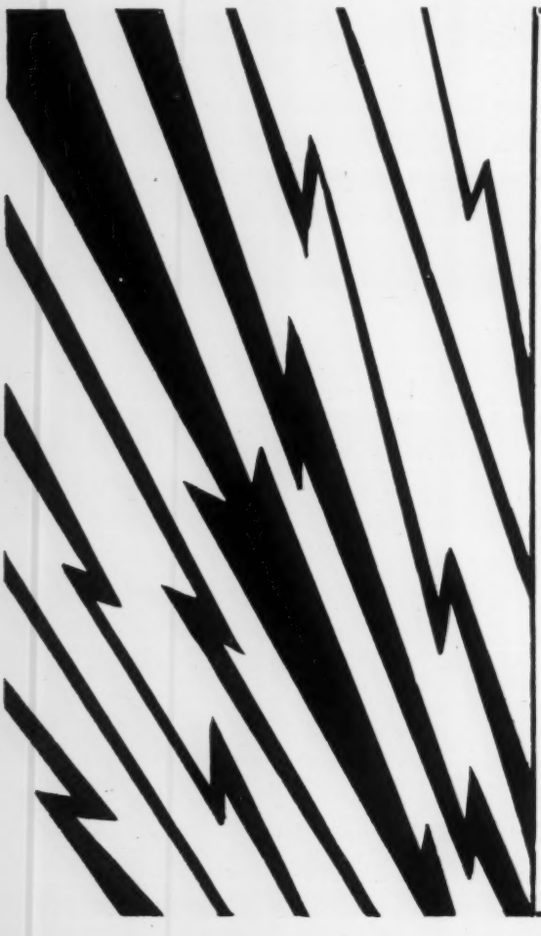
Automotive radiator tube forming machines equipped with twenty-four feed mechanical lubricators

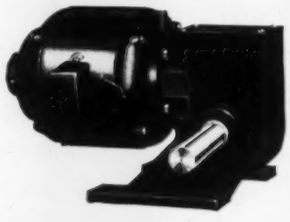
Lubricates Seventy-Two Bearings

PROGRESS in machine design has increased the need for lubricating systems of greater capacity. With efficiency an imperative factor emphasis is being placed on mechanical lubricators employing the force feed principle for supplying machines with a positive system of lubrication. Among producers of these is McCord Radiator & Mfg. Co., Detroit.

Batteries of three twenty-four feed mechanical lubricators installed on machines that form tubes for tubular-type automotive radiators, are shown in the accompanying illustration. Seventy-two bearings in each machine are all served while the shafts are in motion. When the machines stop the supply of lubricant automatically ceases to be fed to the bearings.

Bearings are protected against corrosion, acid and acid fumes aside from the offsetting of friction, by the positive delivery of oil in this manner. Approximately 250 feet of copper tubing is used on each machine connecting the feeds to the lubrication centers. To prevent any waste of oil, reduction gearing is employed.





Complete Slow Speed Drive Assembly—

On numberless motor driven appliances, the Janette Motorized Speed Reducer has proven to be a highly satisfactory slow speed drive assembly.

In one compact machine are combined motor, coupling and speed reducer.

And because of its unique compactness, it makes possible a neater and more machine-like design on equipment which it operates.

Janette Motorized Speed Reducers are quiet, sturdy and inexpensive. 1 30 to 1 3 h.p. Ratios: 20-to-1 to 70-to-1.

Write for Bulletin SR-529

JANETTE MANUFACTURING COMPANY

558 West Monroe Street
CHICAGO

Singer Bldg., 149 Broadway, New York

Real Estate Trust Bldg., Philadelphia

Here's real co-operation!

When considering new equipment, or the modernization of equipment now in operation, you are invited to use the Engineering Service provided by the Hyatt Roller Bearing Company through its various branches.

Specialists experienced in bearing applications of every kind are available for consultation. At your disposal, too, are the experimental facilities of an organization that has specialized in the design and manufacture of one product for nearly forty years.

Applications of Hyatt Roller Bearings to machinery and equipment for practically every branch of manufacturing, mining, road building, oil drilling, agriculture and transportation are covered in a series of engineering bulletins now ready for distribution.

So, whether you need bearings for the equipment you build, or the machinery which helps produce it, let us show you the advantages of Hyatt protection.

HYATT ROLLER BEARING COMPANY

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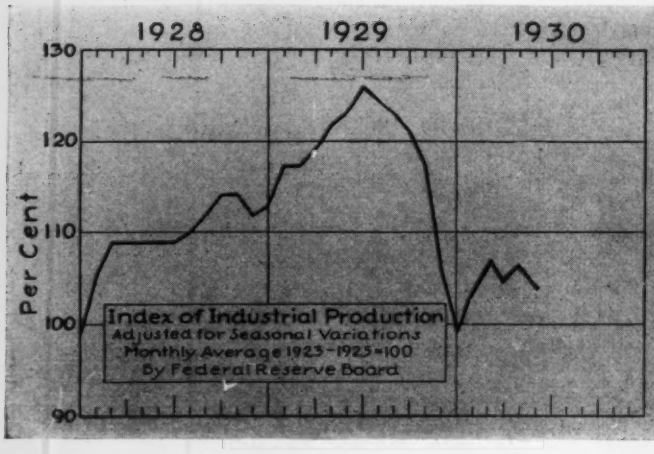
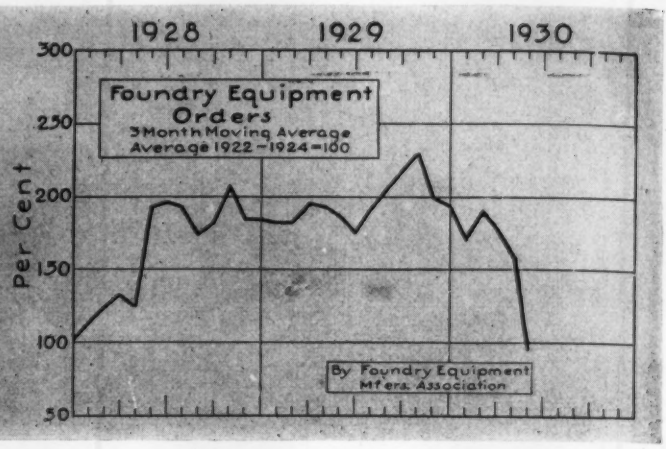
PRODUCT OF GENERAL MOTORS



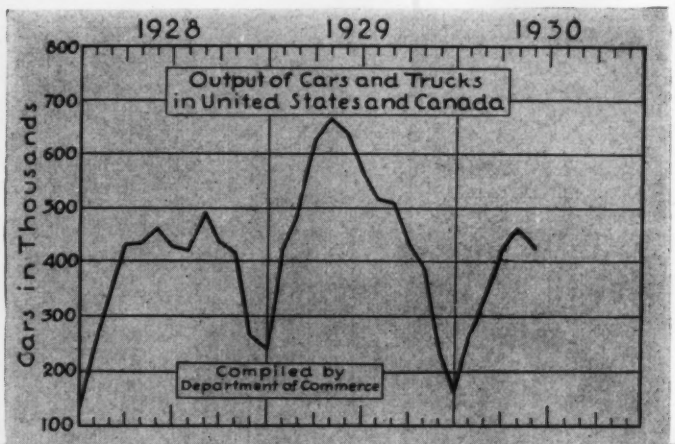


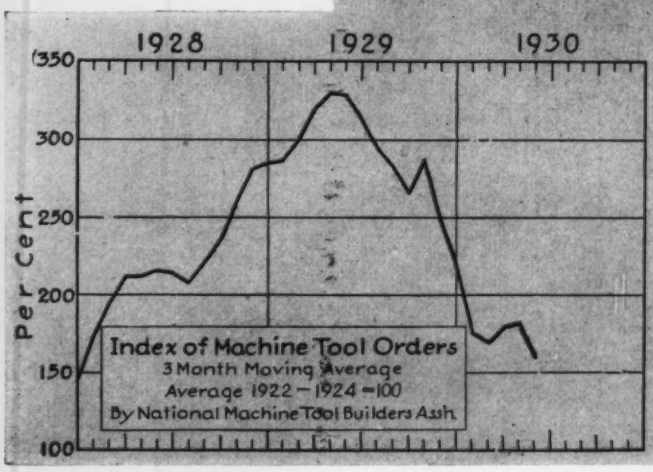
How Is Business?

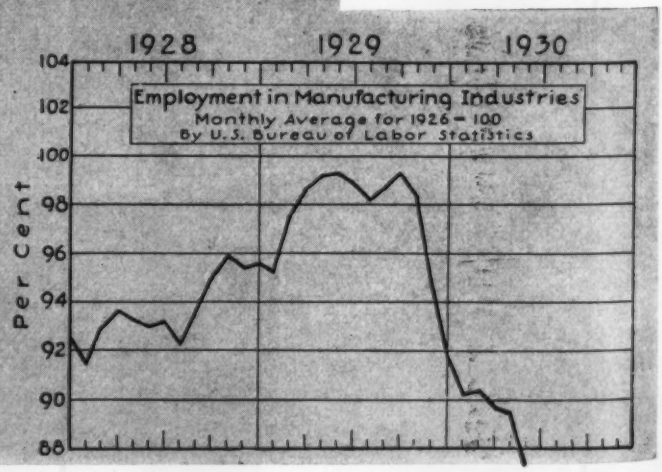
FURTHER adjustment between supply and demand continues through the remainder of the summer leaving autumn as the pivot point for improvement. Optimism is slightly strengthened among industrial leaders. Production in almost every branch of industry had been adjusted according to demand as shown by the fact that rates of operations are fluctuating up and down.

Industrial activity declined again in May. Commodity prices continue a downward swing but less concern prevails compared with the feeling several months ago. This is the reaction of a brighter future outlook. July and August will be dull months for the automotive industry where decided steps have been taken to avoid over production. The machinery market is quiet with export business tapered off. Employment follows a downward tendency but this curve is expected to take an upward trend in the approaching months. The index of foundry equipment orders went to 92.7, the first time it has fallen as low as 100 since 1928. This may be a good indication judging from past records which reveal that rapid recovery followed when the index went below this point.

Steel and iron prices slumped again according to *Steel's* weekly composite of 14 iron and steel products. Copper prices hold at 12.00c. Aluminum ingots and sheets were cut 1 cent. Mild steel bars are being quoted 1.75c. Bars drawn or rolled and shafting are bringing 2.10c per pound. Alloy steel bars, S. A. E. 2300 are priced $4.15 and S. A. E. 3100, $3.20. Yellow brass rods are listed at 17.00.







EFFICIENCY in Sealing ECONOMY of Installation—

This was the goal of Chicago Rawhide engineers in designing the Perfect Oil Retainer. How successfully they achieved their objective is revealed by this significant fact:

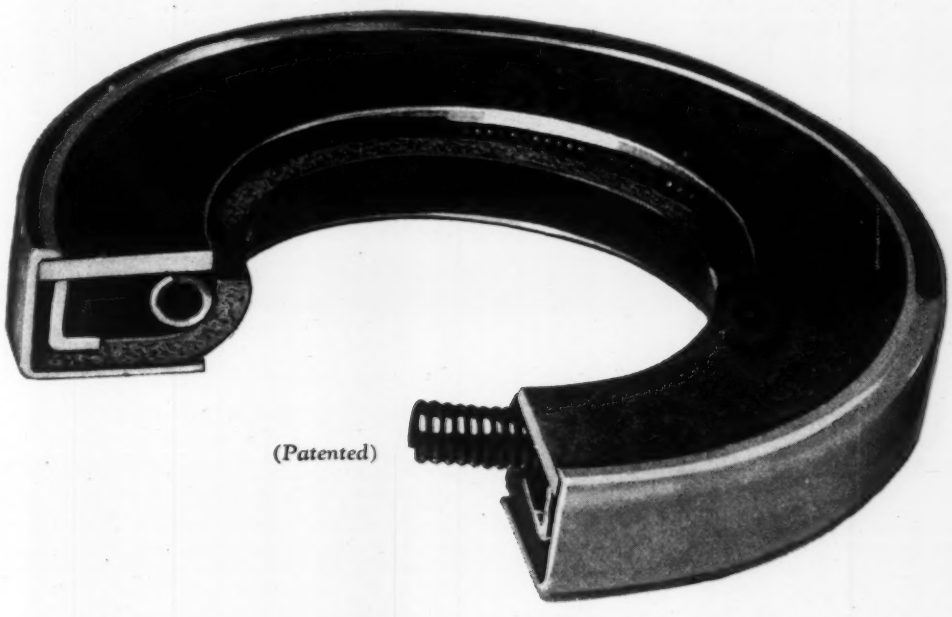
Perfect Oil Retainers are now standard equipment in 90% of all automotive and general machine installations for which self-contained seals are used.

Our special tanning processes prolong the life of the leather packing member indefinitely. Scientifically designed springs hold it against the shaft with exactly the correct pressure, under all operating conditions.

This efficient, economical grease-and-oil seal comes to the machine-builder in a compact assembly, and requires only the simplest of machined recesses in hub, housing or bearing retainer.

The Chicago Rawhide Manufacturing Company

1304 ELSTON AVENUE, CHICAGO, ILL. BRANCHES: New York, Detroit, Cleveland, Philadelphia



(*Patented*)

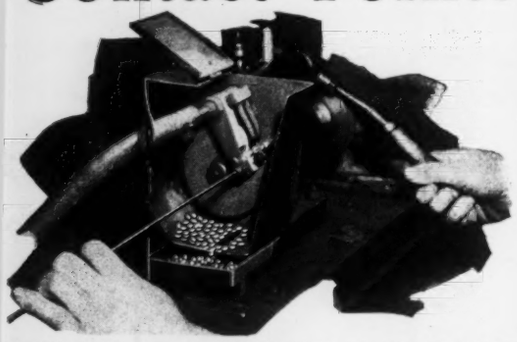
THE PERFECT OIL RETAINER

IF MADE OF LEATHER FOR MECHANICAL PURPOSES WE MAKE IT

RARE METALS AND ALLOYS

TANTALUM · · · TUNGSTEN · · · MOLYBDENUM · · · CAESIUM · · · RUBIDIUM

FANSTEEL
for
Contact Points



"END GRAIN" METAL
feature of
Fansteel Contacts

THIS superior process of making contact points was originated by Fansteel. Instead of the discs being punched from sheets, as is the ordinary method, they are smoothly *sawed* from rods of 99.95% pure Tungsten or Molybdenum under the Fansteel process, making discs *with end grain metal* as a contact surface. Contact Points made this way have a hard, smooth, uniform surface that resists heat and wear, and does not readily stick, pit or flake off. The discs, after repeated inspections, are then securely welded to support members, carefully ground, polished and the complete unit inspected again.

Precision is the Fansteel watchword in refining rare metals, designing and fabricating contact points under the close control of a laboratory staff of eminent metallurgists and engineers.

Fansteel is the source of supply for the best type of contact points—also rare metals and alloys in commercial forms.

TANTALUM · · · TUNGSTEN · · · MOLYBDENUM · · · CAESIUM · · · RUBIDIUM

FANSTEEL PRODUCTS
COMPANY, Inc.
NORTH CHICAGO, ILLINOIS

MEN OF MACHINES

(*Concluded from Page* 56)

meeting of the executive committee held in Cleveland. He succeeds B. F. Waterman, new president of the association. Mr. Ross has been chairman of the herringbone gear committee.

Obituaries

COKER FIFIELD CLARKSON, secretary and general manager of the Society of Automotive Engineers for the past 20 years, died at his home, Scarborough-on-Hudson, N. Y., June 4. He was 60 years old, having been born in 1870 at Des Moines, Iowa. In 1910 he became associated with the Society of Automotive Engineers and under his efficient management the membership grew from 400 to over 7000.

* * *

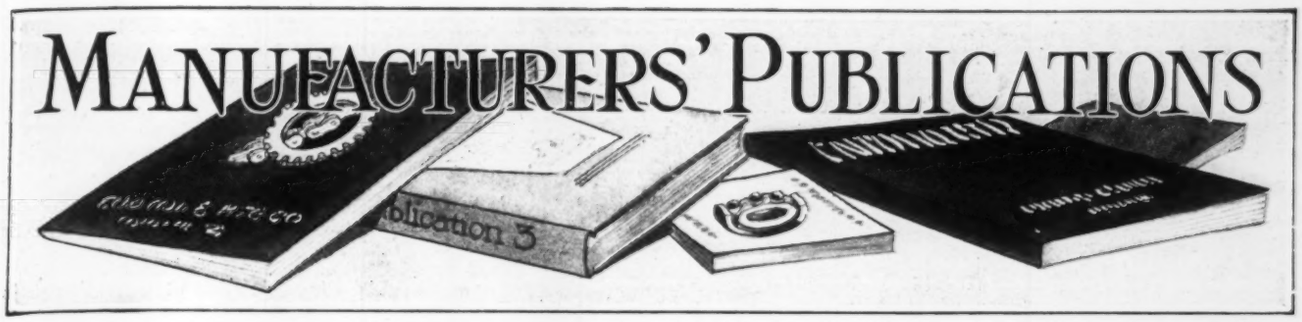
DR. ELMER AMBROSE SPERRY, 70, engineer, inventor and scientist, died June 16 at New York from the effects of an operation. He was born in Cortland, N. Y., Oct. 12, 1860, where he attended State Normal school. He later spent the college year 1879-1880 at Cornell university. In 1880 he founded the Sperry Electric Co., Chicago, and 1890 organized the Sperry Electric Railway Co., Cleveland. Holder of more than 400 patents, mostly upon electrical appliances, Dr. Sperry chiefly is known for the Sperry Gyroscope. He was elected president of the American Society of Mechanical Engineers in December, 1928, and in October, 1929, was presented the Gary Bronze medal by the American Iron and Steel institute.

DR. ELMER A. SPERRY

* * *

ANDREW LAWRENCE RIKER engineer, inventor and pioneer in the development of the automobile in this country, died at his home near Fairfield, Conn., June 1. He was 62 years old. Mr. Riker was 16 when he developed his first electrically propelled automobile and became vice president and chief engineer of the Locomobile Co. of America upon its formation in 1902.

MANUFACTURERS' PUBLICATIONS



Publications listed in this section may be obtained without charge from the manufacturers of the products or through MACHINE DESIGN

MOTORS—In a profusely illustrated booklet recently issued, the Master Electric Co., Dayton, O., shows a wide variety of motor driven machines powered by Master Guaranteed units. Considerations in the purchase of motors and standardizing the motor drive are treated in the text matter.

ALLOY STEEL CASTINGS—Safes of cast alloy steel, tested to resist entry for 45 minutes by any means but the cutting torch or explosives are featured in a bulletin by the Nugent Steel Castings Co., Chicago. Pressures up to 80 tons bent and dented these safes but failed to crack them, as illustrations show.

CHAINS—American Chain Co. Inc., Bridgeport, Conn., has compiled a book on chain for use of engineers, designers and chain users. It covers facts and figures on all types of welded chain, with tables of sizes, weights, loads and directions for taking measurements. Rules and cautions by the Chain institute are included.

SHEET STEEL—Inland Steel Co., Chicago, has issued a booklet and two folders on its sheet steel. Each of many grades of sheet steel is described, standard extras and differentials are given, with tables of tolerances and weights and a section on trade customs and practices. Galvanized and copper alloy sheets are treated in the folders.

ELECTRICAL EQUIPMENT—General Electric Co., Schenectady, N. Y., has issued recent bulletins, as follows: A. C. enclosed magnetic switches for motors; quiet operating induction motors; single-stage centrifugal air compressors for cupola blowing; electric equipment for handling heavy material.

LUBRICATION—Texas Co., New York, in the April number of its publication devoted to that subject, considers tractor lubrication, in which power economy is the ultimate objective. Numerous illustrations show how the matter is handled by various types of tractors.

STEEL CASTINGS—Sivyer Steel Casting Co., Milwaukee and Chicago, has added three looseleaf pages to its bulletins, covering its reversible dipper tooth of interlock and clinch point type, and showing representatives physical properties of Miraculoy, one of its alloy steels. A binder for filing these reports is available from the company.

OIL CIRCUIT BREAKERS—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., has published a leaflet on a new weatherproof oil circuit breaker rated at 400, 600 and 800 amperes, 7500 volts. The leaflet describes in detail the construction of the breaker, supplemented by photographic views. The breaker is made for manual solenoid, D. C. and A. C. rectox operation and these various operating mechanisms are described.

FORGINGS—Camden Forge Co., Camden, N. J., devotes a current bulletin to its forgings for railroad use, a product it has developed for 28 years.

SWITCHES—Allen-Bradley Co., Milwaukee, describes in a current bulletin its line of starters for alternating-current motors, each protected by an across-the-line switch designed for complete safety.

VALVES—Edward Valve & Mfg. Co., East Chicago, Ind., has issued a bulletin on its high pressure valves, giving four reasons for their use in power plants. Ample illustrations show the valves and details, while the text explains their application.

ALLOYS—Niagara Falls Smelting Co., Buffalo, is distributing the second edition of its handbook for foundrymen. It is designed to inform the foundryman as to the use of alloying materials to attain certain results in his castings.

INGOT IRON—American Rolling Mill Co., Middletown, O., is distributing a booklet with the title, "A Visit to Armco with the Iron Master." It is based on a talk given by the Iron Master during recent radio programs and contains an illustrated story of a visit to the company's plant.

SHEAR KNIVES—Heppenstall Co., Pittsburgh, devotes a current bulletin to its shear knives, made for various purposes in cutting metals. Illustrations show processes of manufacture. Information valuable to users of such knives is included and data tables include much useful information.

WATER SCREENS—Link-Belt Co., Chicago, has compiled a booklet on its 1930 model traveling water screen for clearing intake water of debris detrimental to operation of condensers and pumps. Illustrations present cross sections of the complete screen and its cleansing devices and a large number of installations.

CONVEYOR CHAIN—Transue & Williams Steel Forging Corp., Alliance, O., has issued a bulletin on its forged industrial conveyor chain. Illustrations show the forged links and assembled chain. Engineering data also are given.

ELECTRICAL DEVICES—Electrical Association of New York Inc., 100 East Forty-fifth street, New York, has compiled a handbook of electrical information, in twelve sections, compiled by representatives of the twelve branches of the electrical industry. It is written in non-technical language adapted to the understanding of all. Subjects covered are: Illumination, industrial control, heating, material handling, motors, refrigerators, signals,

signs, switchboards and panelboards, tools, ventilation and wiring.

MOTORS—Century Electric Co., St. Louis, in two current bulletins, covers a squirrel cage induction polyphase motor, for multi-speeds, and portable power units for farm application.

PAINT FOR METALS—New Jersey Zinc Sales Co., New York, has issued a booklet on the painting of galvanized iron, which takes up problems relating to protection of zinc-coated surfaces by paint.

STEEL CASTINGS—Commercial Steel Casting Co., Marion, O., subsidiary of the Osgood Co., has issued a bulletin on its open-hearth steel castings, illustrating a variety of products from large to small, indicating the range of work it is equipped to produce.

ISOLATION—Data and details for the application of cork machinery isolation are given in a 5-page folder being distributed by Armstrong Cork & Insulation Co., Lancaster, Pa. Description of its product and diagrams showing typical installations give the designer a broad view of the subject.

IRON CASTINGS—Commercial Steel Castings Co., Marion, O., manufacturer of iron and steel castings, has issued a bulletin in which it calls attention to the merits of high tensile cast iron for many uses and to the care with which this class of work is produced.

ELECTRIC FLOW METERS—Brown Instrument Co., Philadelphia, manufacturer of pyrometers, thermometers and indicating, recording and controlling instruments, has issued a book of instructions for installation and care of electric flow meters, revised from a previous issue. It explains the mechanism and gives instructions for adjustment and other care. Practical suggestions are given for avoiding difficulties and tables of correction factors for pressure, quality and superheat of steam.

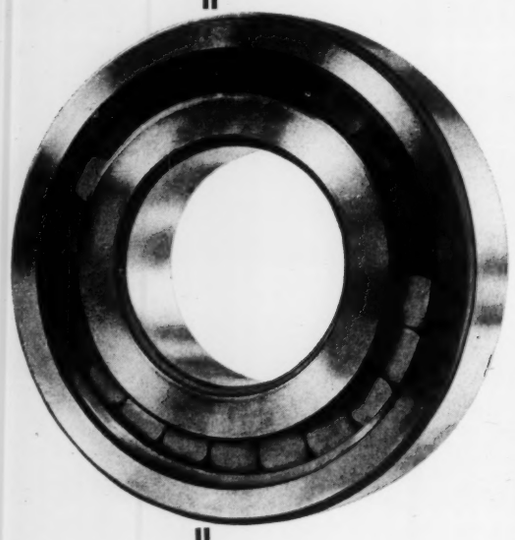
ELECTRICAL DEVICES—Two bulletins by the Sangamo Electric Co., Springfield, Ill., present the company's electrically-wound time switch, which is based on the same principle as its electric clock, and its watt hour meter. Each is illustrated and full description of the devices is given.

ELECTRIC BRUSHES—A series of 12 advertisements of the National Carbon Co. Inc., Cleveland, forms the basis of a booklet telling what is behind the trade mark of the company's brushes. Illustrations show the various steps of manufacture and describes the steps in production of raw material and completed product.

TESTING MACHINES—Southwark Foundry & Machine Co., Philadelphia, has issued a catalog of its testing machines, up to 3,000,000 pounds capacity. Details of construction and operation of the various types of testing machines are described and illustrated. Halftones, diagrams and tables of data are included.

ELECTRICAL EQUIPMENT—Four booklets covering "Steam Turbines," "Power in Flight," "Electrical Equipment for Cotton Gins," and "Electric Motor and Control Equipment for Deck Auxiliaries," recently were issued by General Electric Co., Schenectady, N. Y. Comprehensive text matter and illustrations complete the publications.

MOTORS—Reliance Electric & Engineering Co., Cleveland, recently issued a 15-page booklet describing its type AA induction motors. The contents cover details of design and construction and give a comprehensive picture of the qualifications of the unit. Illustrations supplement the text. Tables of ratings also are given.

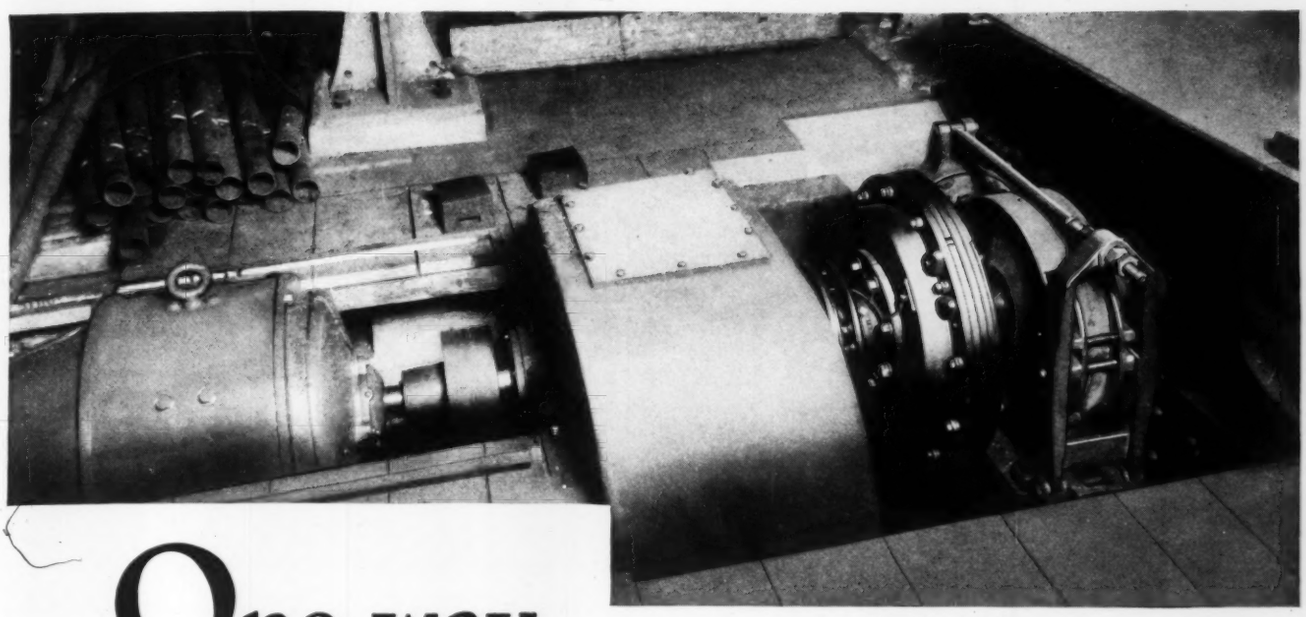


SAFETY

Under the crushing impact of rolling mills, Rollway bearings have demonstrated their capacity. In mill motors reversing many times a minute they have evidenced durability. In spindle applications requiring the greatest precision the workmanship in them is revealed.

And of durability, capacity and workmanship is created the margin of safety which means so much—to dependability, longevity, maintenance economy and workman security.

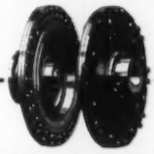
ROLLWAY BEARING COMPANY INCORPORATED
SYRACUSE NEW YORK
ROLLWAY CYLINDRICAL ROLLER BEARINGS



One way to write an effective "sales story"

C-H MAGNETIC CLUTCHES ON GEARS & FORGINGS, INC. WORM-GEAR DRIVE

Every machine-builder wants to provide trouble-free service; every customer wants to buy it. Gears & Forgings, Inc., Cleveland, Ohio, used a C-H Magnetic Clutch in the worm-gear drive shown above—and they advertise: "INSTALL THIS DRIVE . . . and forget about it". On this installation the G. & F. Drive, transmitting power to a pipe-bending machine, has been operating perfectly for years and the only attention it gets is periodic lubrication. Perhaps C-H Magnetic Clutches can help you provide a greater degree of trouble-free service in your product.



C-H Magnetic Clutches consist simply of two plates. They are engaged by magnetism, pressure being self-contained. Engagement of driven member with driving member running at full speed is smooth, jerkless, without grab or bounce, without shock to equipment.

SALESMEN are always hard-pressed for sales-points to make the prospect forget price-arguments.

Here is one way an increasing number of machinery-builders are "writing" a new and powerful sales story for their men . . . through the investigation, and adoption into their design, of C-H Magnetic Clutches.

Briefly, C-H Magnetic Clutches provide automatic operation, eliminate parts and reduce power-wastes. They are sturdy, rugged, simple . . . fitting in well with installations you want to "stay put" without trouble or attention.

A C-H Magnetic Clutch consists of two simple plates which are engaged by magnetism. They eliminate the need of toggle-joints, sliding collars, pivoted arms or heavy back-up parts. They eliminate end- or side-thrust. They are engaged by means of push-buttons, foot-pedals, or automatically with limit-, pressure-, float-switches and the like. They engage under any condition, smoothly, without jerk or jar . . . increasing machine and motor life appreciably.

Only investigation will show you whether you can apply them or not. The profitable possibilities . . . the fact that they today are serving on more than 3 million horse power . . . make that study worth while. Numerous suggestive applications are shown in the booklet CL-1. Send for a copy.

CUTLER-HAMMER, Inc.
Pioneer Manufacturers of Electric Control Apparatus
1326 St. Paul Avenue MILWAUKEE, WISCONSIN

CUTLER HAMMER

Magnetic Clutches Save Time and Save Equipment

(A-337)